FINAL ALTERNATIVES ASSESSMENT
FOR OTHER CONTAMINATION SOURCES
INTERIM RESPONSE ACTION
RAIL CLASSIFICATION YARD, RMA

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October 1989

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1. AGENCY USE ONLY *(Leave Blank)*

2. REPORT DATE
10/00/89

3. REPORT TYPE AND DATES COVERED
FINAL

4. TITLE AND SUBTITLE
ALTERNATIVES ASSESSMENT FOR OTHER CONTAMINATION SOURCES, INTERIM RESPONSE ACTION, RAIL CLASSIFICATION YARD, RMA, FINAL

5. FUNDING NUMBERS
NONE

6. AUTHOR(S)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
MK-ENVIRONMENTAL SERVICES

8. PERFORMING ORGANIZATION REPORT NUMBER
89262R02

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSERING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
NONE

12a. DISTRIBUTION/AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

THIS DOCUMENT DESCRIBES THE PROCESS AND RESULTS OF THE ALTERNATIVES ASSESSMENT CONDUCTED FOR THE RAIL CLASSIFICATION YARD. THE SITE CHARACTERIZATION INVESTIGATION HAS TENTATIVELY IDENTIFIED THE HOLDING TRACKS AS THE SOURCE OF THE DBCP PLUME.
THE ASSESSMENT IS DIVIDED INTO THE FOLLOWING SECTIONS:
1. SITE CHARACTERIZATION (SEE ALSO APPENDIX A)
2. TECHNOLOGY ALTERNATIVES
3. ALTERNATIVE EVALUATION
4. SELECTION OF PREFERRED ALTERNATIVE - CONTAINMENT
5. BORE LOGS AND CONE PENETRATION TESTS
6. ANALYTICAL DATA - GROUND WATER QUALITY, SOIL GAS TESTS.

14. SUBJECT TERMS
IRA L, EXCAVATION, TREATMENT, HYDROLYSIS, BIODEGRADATION, INCINERATION

15. NUMBER OF PAGES
28,APP.A:H

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT
UNCLASSIFIED

18. SECURITY CLASSIFICATION OF THIS PAGE

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

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AUGUST 1989

1. COMMENT:

Page 3, Section 2.0, Interim Response Action Objectives, the objective is limited to dibromochloropropane (DBCP). Please consider whether any other contaminants, treatable by GAC, in the Railyard Area, identified in the Western Study Area Report, could be addressed by this IRA.

RESPONSE:

Other organic groundwater contaminants were not addressed by this IRA because either the detections of other compounds were isolated and not repeated, or the concentrations were well below the respective ARAR.

Additional organic contaminants detected in groundwater in the railyard area from the WSAR included chloroform, benzene, toluene, and hexachlorocyclopentadiene. Benzene and toluene appear to have been isolated, non-repeated detections, that may be false positives. Regardless, benzene and toluene, as well as hexachlorocyclopentadiene, would be removed by a granulated activated charcoal (GAC) treatment system.

Although GAC is ineffective in removing chloroform from groundwater, such treatment does not appear to be necessary. The highest concentration of chloroform detected in the railyard was 18 ug/l, which is well below the proposed ARAR of 100 ug/l.

2. COMMENT:

Page 4, all of the stated criteria for alternative assessment were not evaluated in the text: costs, ARARs attainment, long-term effectiveness, and protection of human health and the environment were not specifically discussed in the alternative evaluation.

RESPONSE:

The stated objective of this IRA is to limit the migration of DBCP near the source area as soon as practicable. To meet this objective, groundwater interception technology is chosen as the preferred alternative. The assessment criteria are not addressed because a specific intercept system is not chosen as a preferred alternative. These criteria will be

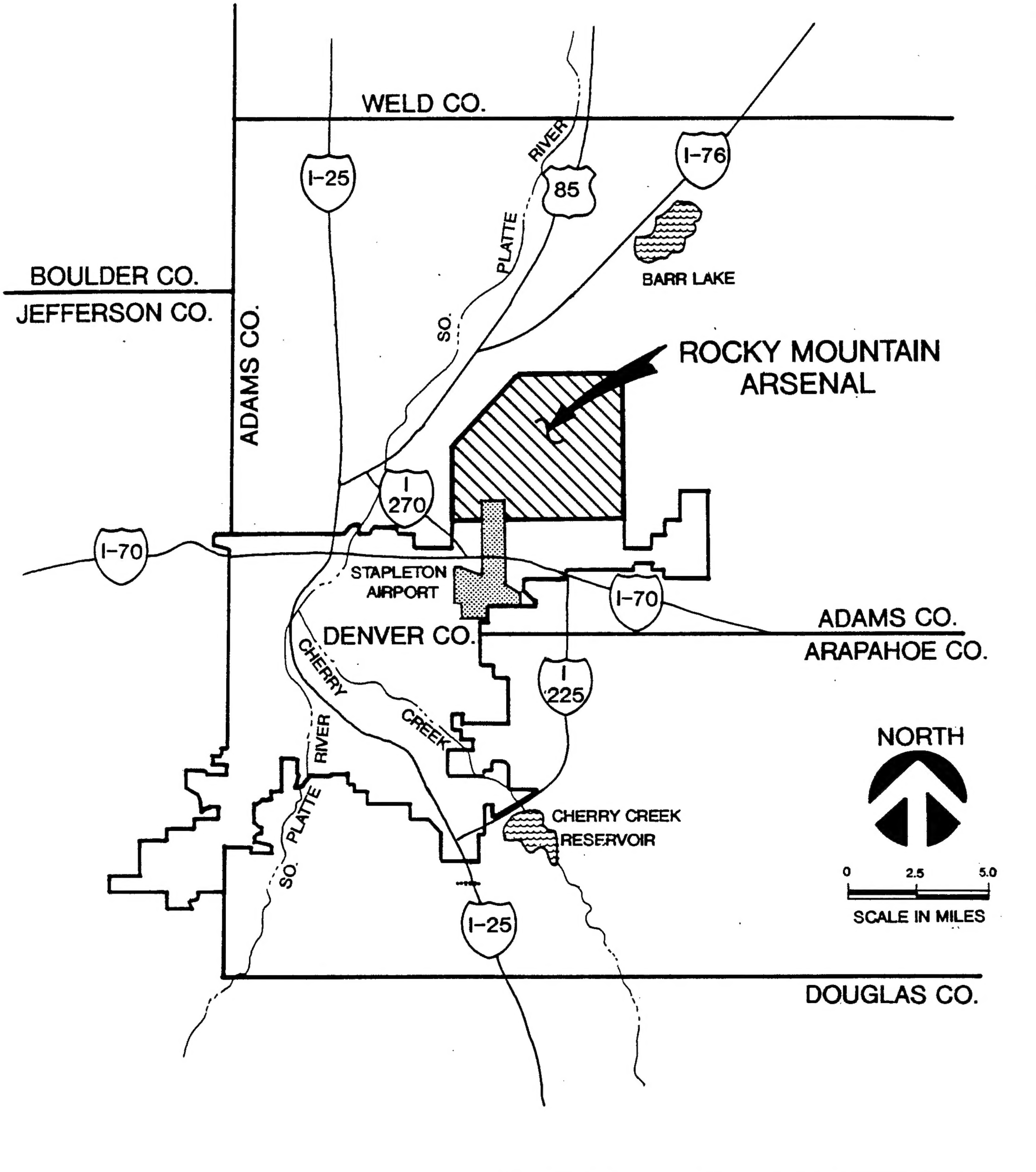

Figure: 1

LOCATION MAP OF R M A

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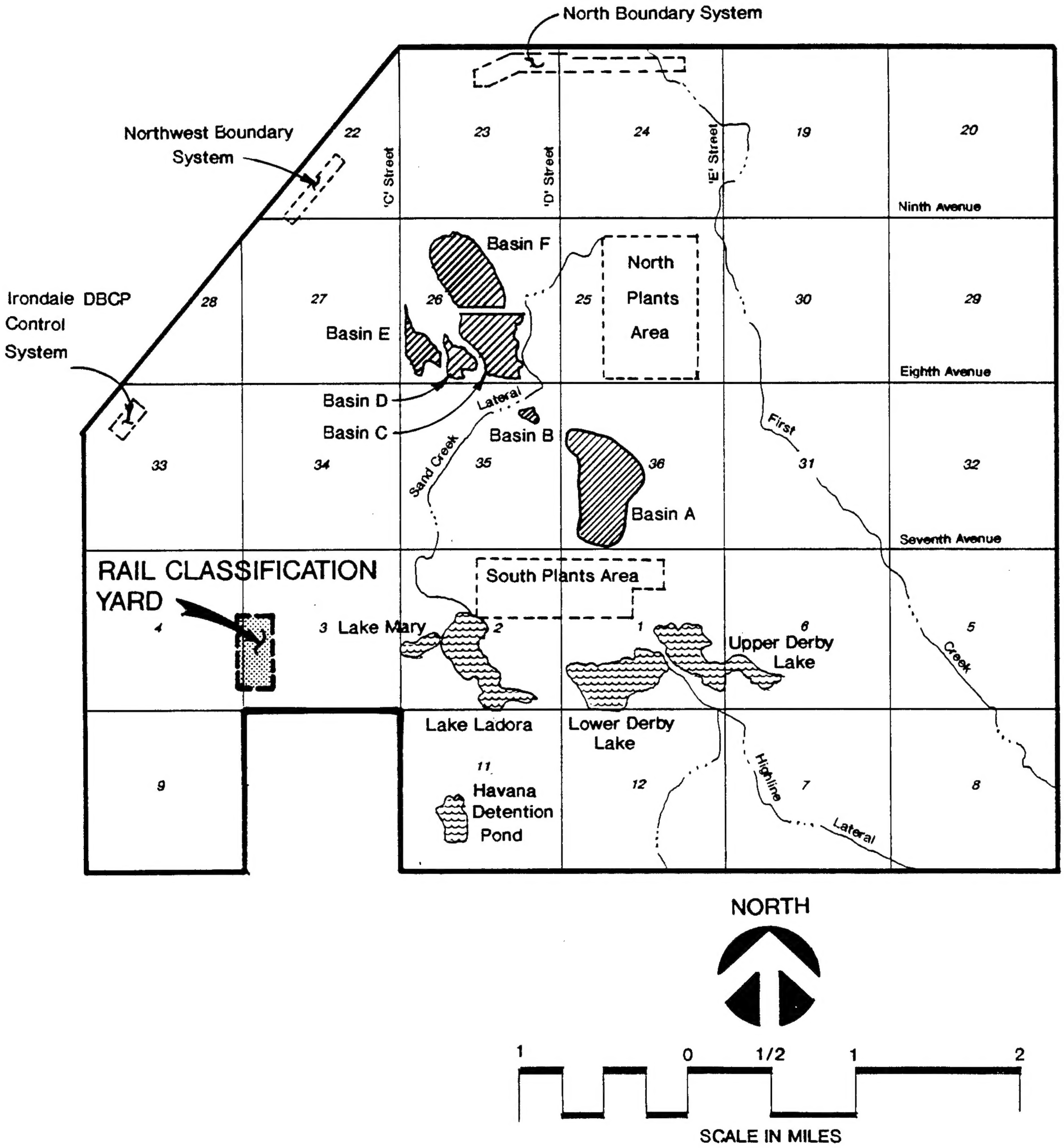

Figure: 2

LOCATION MAP OF RAIL CLASSIFICATION YARD

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used to evaluate and select which intercept system configuration is preferred in the Decision Document.

Field investigations determined that remediation of the source is not feasible as an interim response action because of the complexity of the site. Detailed discussion of the various assessment criteria for source-related alternative technologies is therefore not necessary.

3. COMMENT:

Page 9, Section 4.4, second paragraph, please expand the text to explain the statements that the concentration of DBCP in groundwater consistently decreases with depth. Please expand the basis for this statement and the assessment made to confirm this statement.

RESPONSE:

Section 4.0 of the Alternative Assessment Document is a summary of the railyard site characterization. A more detailed description of the results of the site investigation is included as Appendix A. Within Appendix A, groundwater quality and vertical distribution of DBCP in the alluvial aquifer are discussed in Section 2.3, beginning on Page A-10. The groundwater quality data are listed in Tables A-3 and A-4, and the vertical distribution of DBCP is illustrated in Figures A-8 and A-9.

Groundwater samples were collected from more than one depth in eleven of the CPT borings in order to investigate the vertical distribution of DBCP. Typically, one sample was collected from the upper two feet of the saturated zone, and one was collected from the lowermost permeable zone above the Denver Formation bedrock. The DBCP concentration decreased with depth in the aquifer in eight of the eleven CPT locations and in the 2-well cluster (Wells 03502 and 03503) located within the plume.

4. COMMENT:

Page 9, Section 5.2, Groundwater Interception/Containment, the text states that DBCP is the only contaminant of concern in the railyard area groundwater. However, the maps presented in the Comprehensive Monitoring Program (CMP) Annual Groundwater Report for 1988 indicate that a chloroform plume exists in the railyard area, and that the railyard could be the source of the chloroform plume. Please consider whether treatment of the chloroform plume could also occur.

RESPONSE:

The distribution of chloroform in groundwater in the railyard area is erratic and a plume is not defined. The highest

concentration of chloroform detected in the groundwater was 18 ug/l (WSAR). The ARAR for chloroform is 100 ug/l. Treatment of the groundwater to remove chloroform does not appear to be necessary. Please see the response to Comment 1 for additional details.

5. COMMENT:

Page 21, Section 5.5.2, Incineration, it should be noted that the vapors from DBCP have very low permissible exposure limits under OSHA. The impact of incineration on the developed urban area would have to be evaluated to determine the risk potential.

RESPONSE:

We agree. The last paragraph on Page 21 states, "Air pollution control equipment and monitoring would be required to ensure compliance with air quality regulations." This requirement would include evaluation of risk and compliance with the OSHA PEL. However, incineration is not part of the preferred alternative and such exposure to DBCP will not be possible.

6. COMMENT:

Page 23, the capping alternative was to be considered only in conjunction with other alternatives to prevent further leaching of DBCP from the unsaturated soils; however, the final assessment fails to consider the combination of two or more alternatives as a preferred option.

RESPONSE:

The distribution and migration pathways of DBCP in the vadose zone are very complex. Vapor phase transport of DBCP is a possible mechanism of migration in the vadose zone and could act as a source of DBCP to the groundwater. If this is the case, capping would not prevent DBCP from contaminating the groundwater. Further investigations are required to characterize the source of the DBCP plume for final remediation. Until this characterization is completed, implementing technologies related to remediation of soil contamination is inappropriate. Therefore, the associated technologies, including capping, are not included in the IRA preferred alternative, but may be addressed in the Final Remedy.

7. COMMENT:

Page 25, please specify the disposal method for the spent carbon from the DBCP treatment system. DBCP has such a low PEL that landfilling and not reactivation is often the preferred disposal/reuse option. Further, the carbon loading

with DBCP is restricted, if regeneration is anticipated; this could impact the option of utilization of the Irondale Boundary Containment System to treat the Railyard contamination.

RESPONSE:

The current method of spent carbon disposal used at the Irondale DBCP Control System (ICS) would also be used for a GAC treatment system. The loaded carbon is considered a hazardous waste and handled appropriately. It is reprocessed for industrial use only.

At the ICS, the loaded carbon is removed from the system before its full loading capacity for DBCP is reached. As a result, carbon consumption is relatively high but carbon loading restrictions should not be a factor. Additional treatment capacity may be available at the ICS because only two of the three adsorbers are currently in use.

4.0 SITE CHARACTERIZATION

Section 4.0 is a summary of the railyard site investigation. A detailed description of field methods and results of the site characterization are included as Appendix A.

4.1 PURPOSE AND SCOPE

Water quality data acquired to date indicate the source area of the DBCP plume is located within the railyard. This site investigation was undertaken to assist in assessment of Interim Response Action (IRA) alternatives by better defining the boundaries of the source of the DBCP plume. The following tasks were conducted:

1. Installation of four alluvial groundwater monitoring wells and one alluvial aquifer test well;

2. Sampling and analysis of groundwater from the four new monitoring wells and two existing alluvial monitoring wells;

3. Completion of an aquifer test in the new test well;

4. Completion of a soil gas survey, including soil sampling and analysis, in areas of potential soil contamination;

5. Completion of a cone penetrometer survey, including groundwater sampling and analysis; and

6. Evaluation of hydrogeologic, soil, and water quality data.

4.2 DISCUSSION OF PREVIOUS INVESTIGATIONS

This investigation utilized all soil and water quality data previously collected in the railyard.

In 1982, the Army installed and sampled six soil borings in the railyard area. DBCP was detected in soil samples from three of the six borings (Geraghty and Miller, 1982).

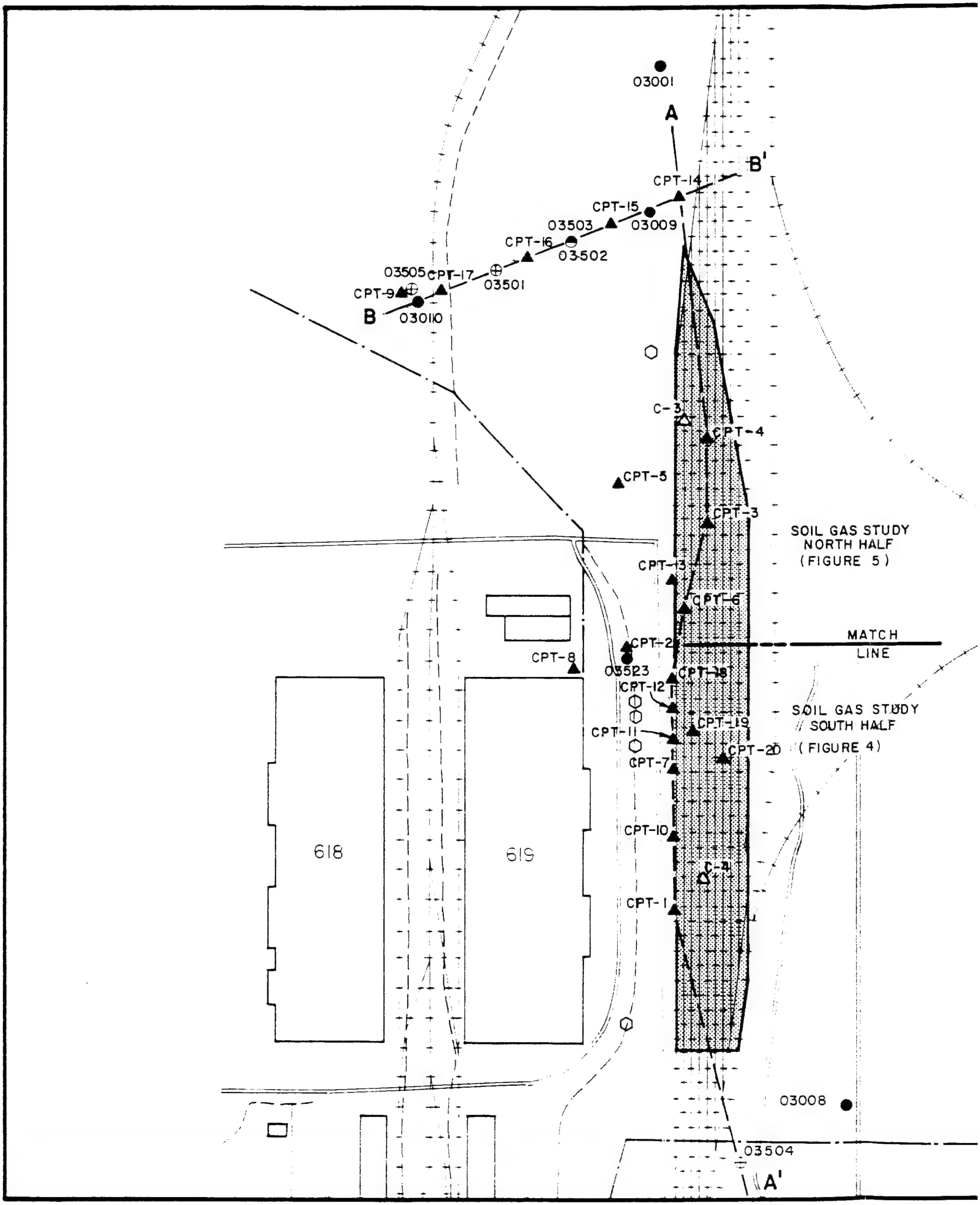
An extensive soil sampling program, including a Petrex soil gas survey, was conducted by the Army and presented in the Site 3-4 Contamination Assessment Report (Ebasco, 1988, 1988a). DBCP was detected at one sampling location in the soil gas survey, and was later confirmed by two Phase II soil samples. This area was evaluated further during this investigation.

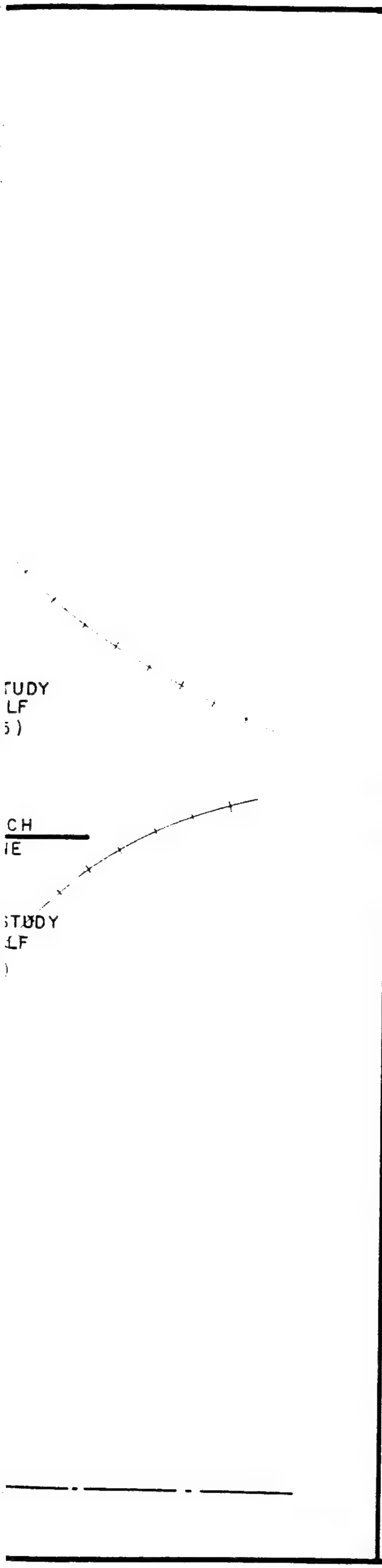
Since 1981, quarterly groundwater sampling has been conducted by the Army and/or Shell to monitor the DBCP plume and evaluate the effectiveness of the Irondale Boundary System (IBS). Approximately seventy monitoring or extraction wells on- and off-post have been sampled each quarter. Water level measurements have been recorded for these wells, plus approximately forty others (Whitten and May, 1983; Thompson and Whitten, 1985; Swift and Chiang, 1987; PMSO, PMA, 1988; and Shell files, 1989).

All soil and water quality data collected in the railyard area for the Remedial Investigation were compiled in the Western Study Area Report (Ebasco, 1989). The presence of DBCP and other compounds in the soil and groundwater was described.

4.3 METHODOLOGY

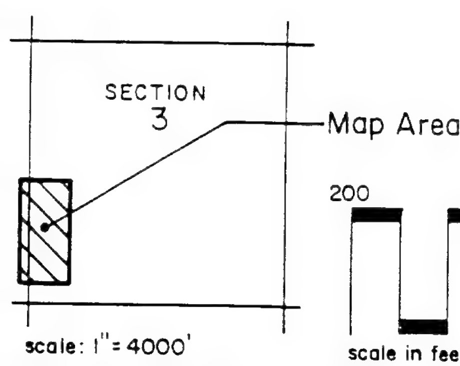
In March 1989, five new alluvial wells were installed in the railyard area (03501-03505); four are located downgradient, while one is upgradient (Figure 3). Of the four downgradient wells, two comprise a paired cluster well (03502 and 03503) and one Well 03505 is an aquifer test well. Four of the new wells


03001
A
B'
CPT-14
CPT-15
03009
03503
CPT-16
03502
03505
CPT-17
03501
CPT-9
03010
B
C-3
CPT-4
CPT-5
CPT-3
SOIL GAS STUDY
NORTH HALF
(FIGURE 5)
CPT-13
CPT-6
MATCH
LINE
CPT-2
CPT-8
03523
CPT-18
CPT-12
SOIL GAS STUDY
SOUTH HALF
(FIGURE 4)
CPT-19
CPT-11
CPT-20
CPT-7
618
619
CPT-10
C-4
CPT-1
03008
03504
A'



Legend

- 619 — Building
- Road
- Railroad
- Sanitary Sewer
- Drainage
- Previously Existing Alluvial Monitoring Well
- Newly Installed Alluvial Monitoring Well
- Newly Installed Alluvial Cluster Well
- Cone Penetrometer Test Boring
- Groundwater Sampling Location Only
- Tracer Research Soil Gas Study Area
- Soil Sample Location
- Cross-Section Location



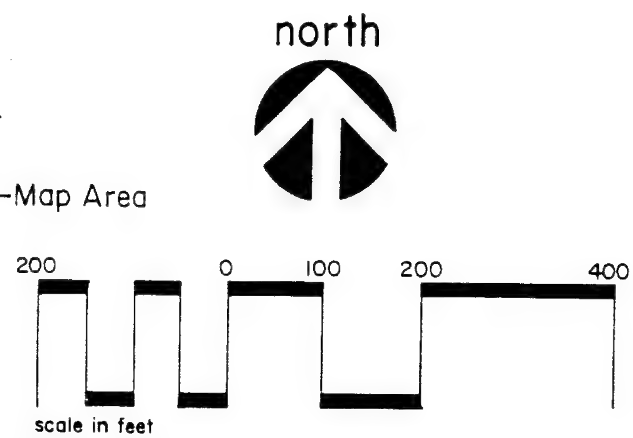


Figure: 3

Field Investigation and Cross-Section Location Map

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(03501-03504) and two existing wells (03001 and 03010) were sampled in April 1989 and analyses were performed by a contract laboratory using USATHAMA-certified GC methods for DBCP. Although other compounds occur in alluvial groundwater beneath the railyard area (Ebasco, 1989), DBCP was the only compound investigated in this study because it comprises the plume that emanates from the railyard.

A soil gas test survey was conducted in February 1989 and an extensive shallow soil gas investigation of the railyard was performed in June 1989. Real time soil gas and soil extraction methods were used to analyze a total of 350 samples.

In June and July 1989, lithologic, hydraulic, and water quality data were collected during a cone penetrometer survey. Cone penetration testing (CPT) was conducted at 22 locations (Figure 3); groundwater samples and lithologic data were collected from 20 of the 22 sites. Two of the sites that groundwater samples were collected did not have lithologic data collected and vice versa. Real time analyses of groundwater samples were necessary to direct the CPT investigation and were performed onsite using EPA Method 504 for DBCP. A total of 53 groundwater samples were analyzed.

4.4 RESULTS

The railyard is underlain by approximately 65 feet of alluvium comprised primarily of well graded sand and gravelly sand with minor lenses of less permeable clayey sand and clay. The alluvium is underlain by claystone and shale of the Denver Formation.

The water table occurs in alluvium approximately 55 to 75 feet below ground surface. As indicated from the northeasterly sloping water table, groundwater flows from the south to the north-northwest. Lateral hydraulic gradients range from 0.02

ft/ft in the south to 0.006 in the north; hydraulic conductivity is approximately 1.3 x 10^{-3} ft/sec (4.0 x 10^{-2} cm/sec).

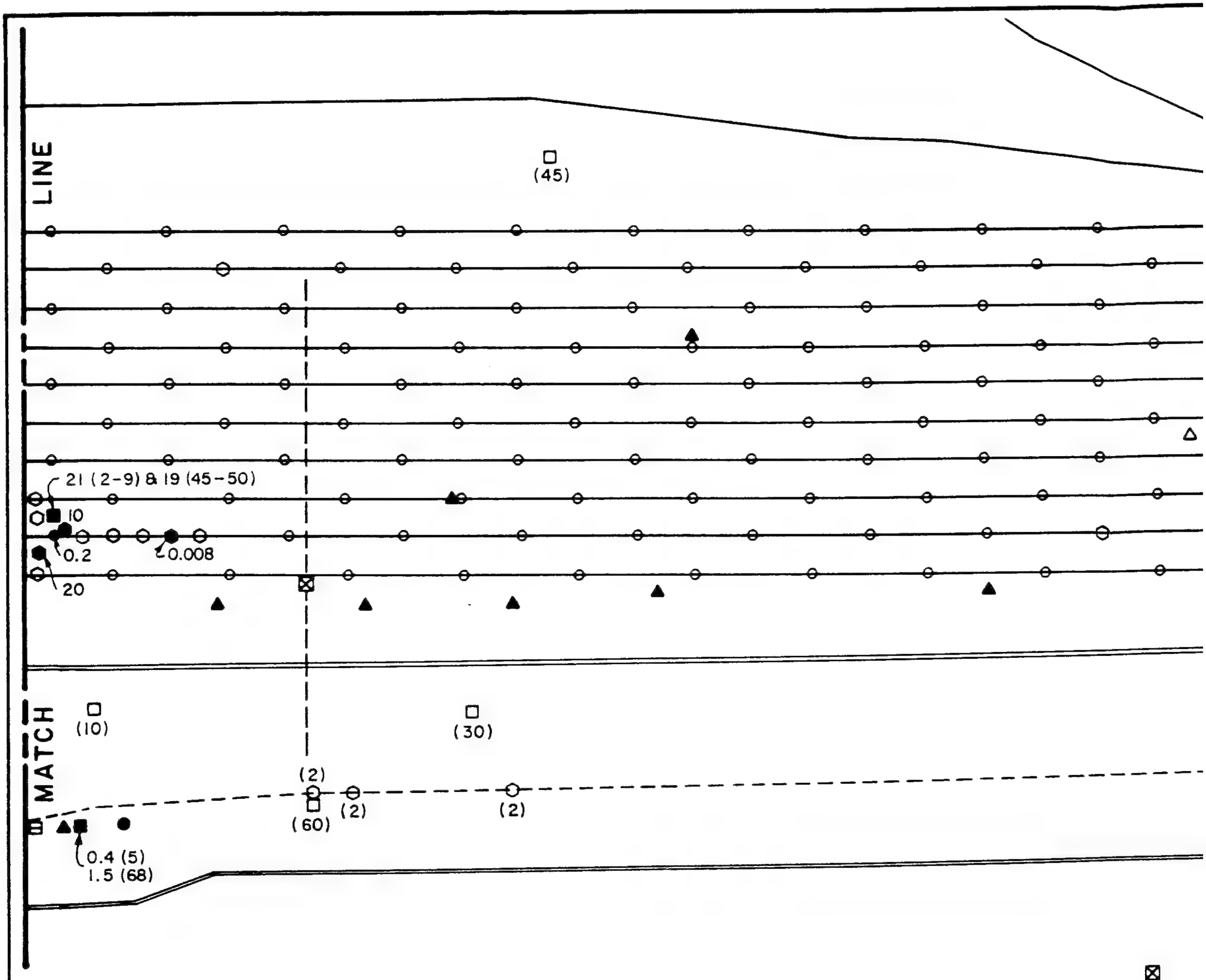
The distribution of DBCP in soil gas was investigated to identify areas of soil contamination that may be surficial expressions of the sources of DBCP to the groundwater plume. The results of the soil gas survey are shown in Figures 4 and 5.

The highest concentrations of soil gas occurred in the Test Survey Site shown on Figure 5. This site is located immediately north of CPT-6 on Figure 3. Soil and soil gas concentrations within this site are shown in detail in Figure 6.

As shown in Figure 6, concentrations in soil samples ranged from 2000 ppb near ground surface to 70 ppb twenty feet below ground surface. Increases in concentration (from 50 to 100 ppb) occurred at approximately 4 to 6 feet below ground surface and between 15 and 20 feet below ground surface (from 10 to 70 ppb). These increases correlate with lenses of clayey sand and clay that occur at approximately 7 and 20 feet below ground surface. These lenses, plus one 45 feet below ground surface, appear to dip to the southwest. They may have inhibited vertical migration of residual or vapor-phase DBCP from surface sites (e.g., the Test Survey Site), while allowing lateral flow to the southwest toward Well 03523 and CPT-12.

Figure 7 shows the distribution of DBCP in groundwater collected from wells and CPT holes near the railyard. As shown in the figure, the configuration of the upgradient end of the plume is not well defined but is interpreted to have fingers of contamination emanating from several small low concentration sources.

The highest concentrations in groundwater near the upgradient end of the plume occur in CPT-12 and Well 03523. These sample locations are upgradient of and lateral to the highest concentrations detected in surficial soil gas (i.e., the Test



Legend

ROAD
RAILROAD TRACK
SURFACE DRAINAGE
TRACK DRAINAGE
CATCH BASIN

MONITORING WELLS

PREVIOUSLY EXISTING ALLUVIAL MONITORING WELL
NEWLY INSTALLED ALLUVIAL MONITORING WELL
NEWLY INSTALLED ALLUVIAL CLUSTER

CONE PENETRATION TEST BORINGS

LITHOLOGY PROFILE AND GROUNDWATER SAMPLING LOCATION.
GROUNDWATER SAMPLING LOCATION ONLY.

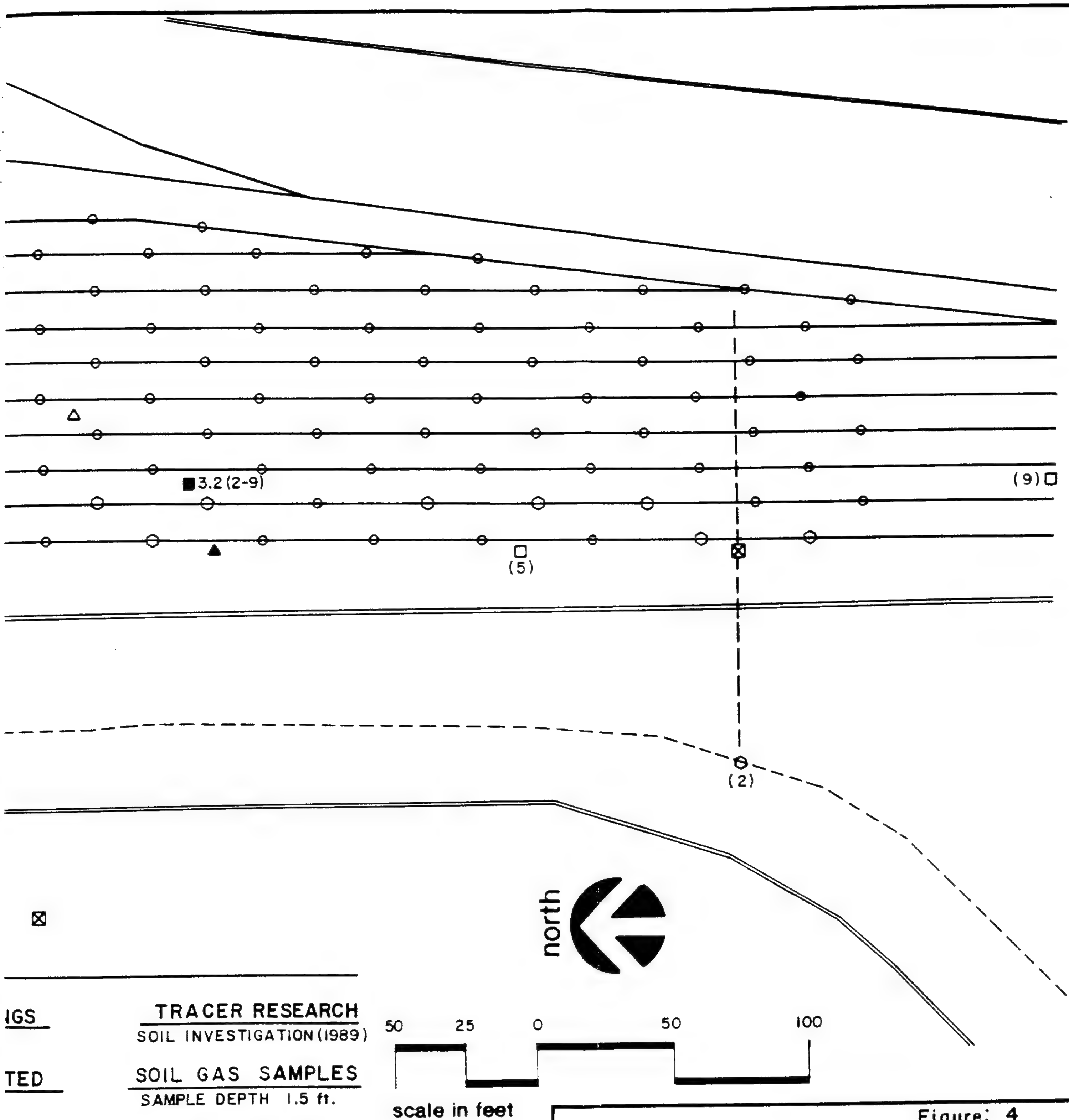
ARMY SOILS BORINGS

DBCP DETECTED

21 (2-9)
SAMPLE DEPTH (ft)
DBCP, ug/g x 10^3

DBCP NOT DETECTED

(60)
MAXIMUM SAMPLE DEPTH (ft)



IGS

TED

EPTH (ft)

0^3

TECTED

PLE

TRACER RESEARCH
SOIL INVESTIGATION (1989)

SOIL GAS SAMPLES
SAMPLE DEPTH 1.5 ft.

● DBCP DETECTED
0.2 DBCP, ug/ℓ

○ DBCP NOT DETECTED

SOIL EXTRACTION SAMPLE
SAMPLE DEPTH 2 ft.

⬢ DBCP DETECTED
20 DBCP, ug/g x 10^3

⬡ DBCP, NOT DETECTED

Figure: 4

Distribution of Dibromochloropropane In Soil

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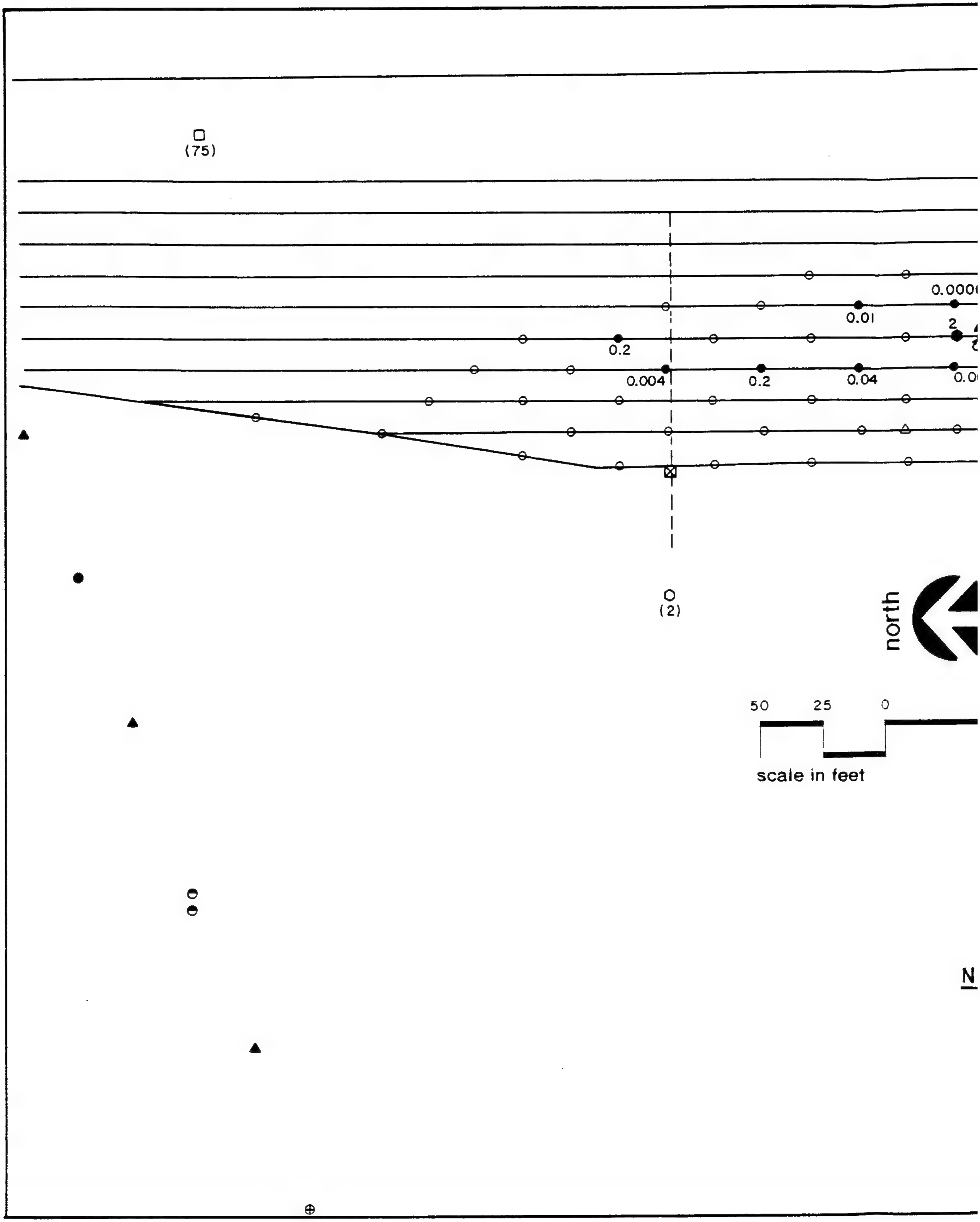
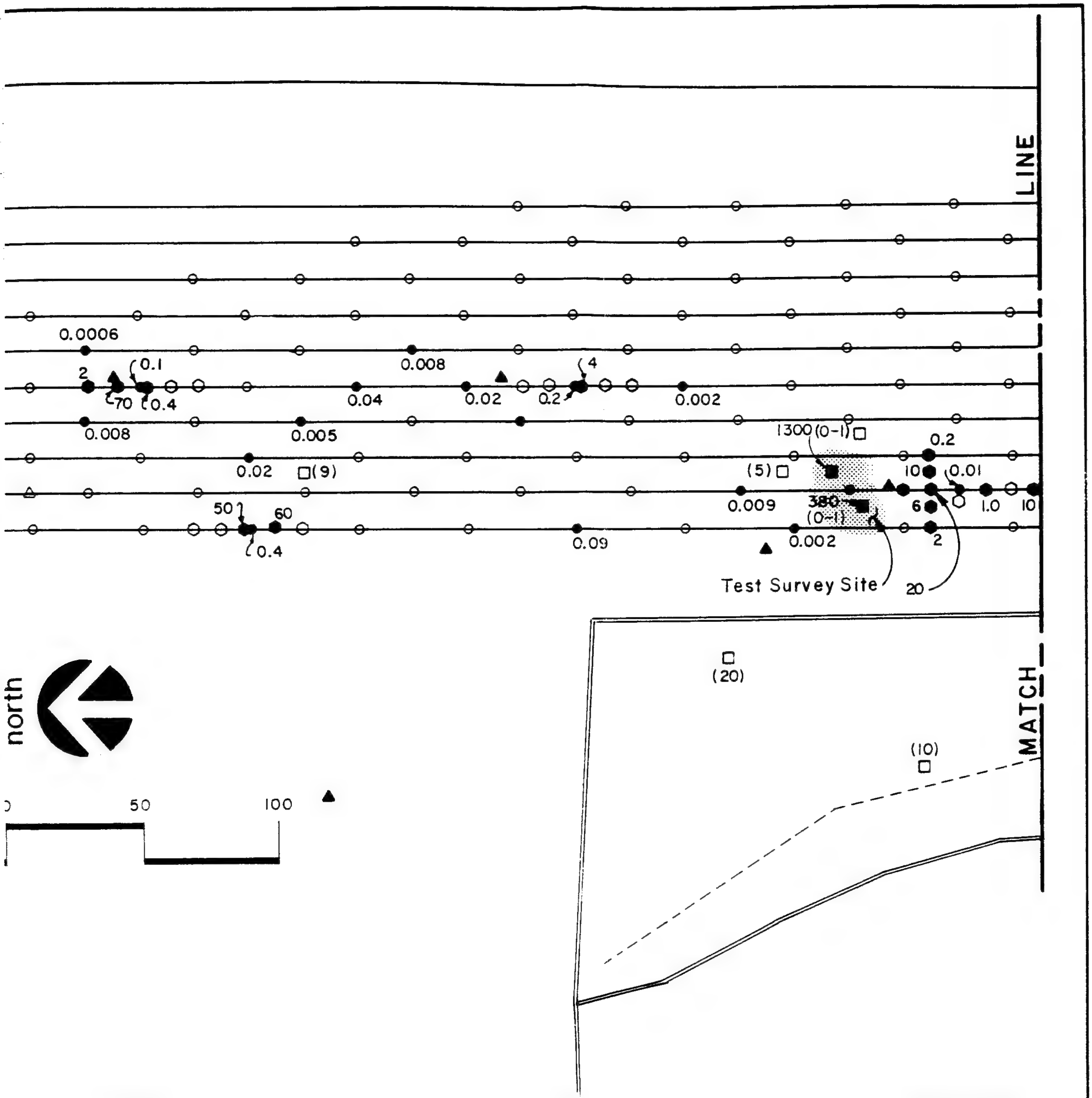


(75)
0.01
2
0.2
0.004
0.2
0.04
(2)
north
50
25
0
scale in feet



NOTE:

SEE FIGURE 4 FOR LEGEND

Figure: 5

Distribution of Dibromochloropropane in Soil

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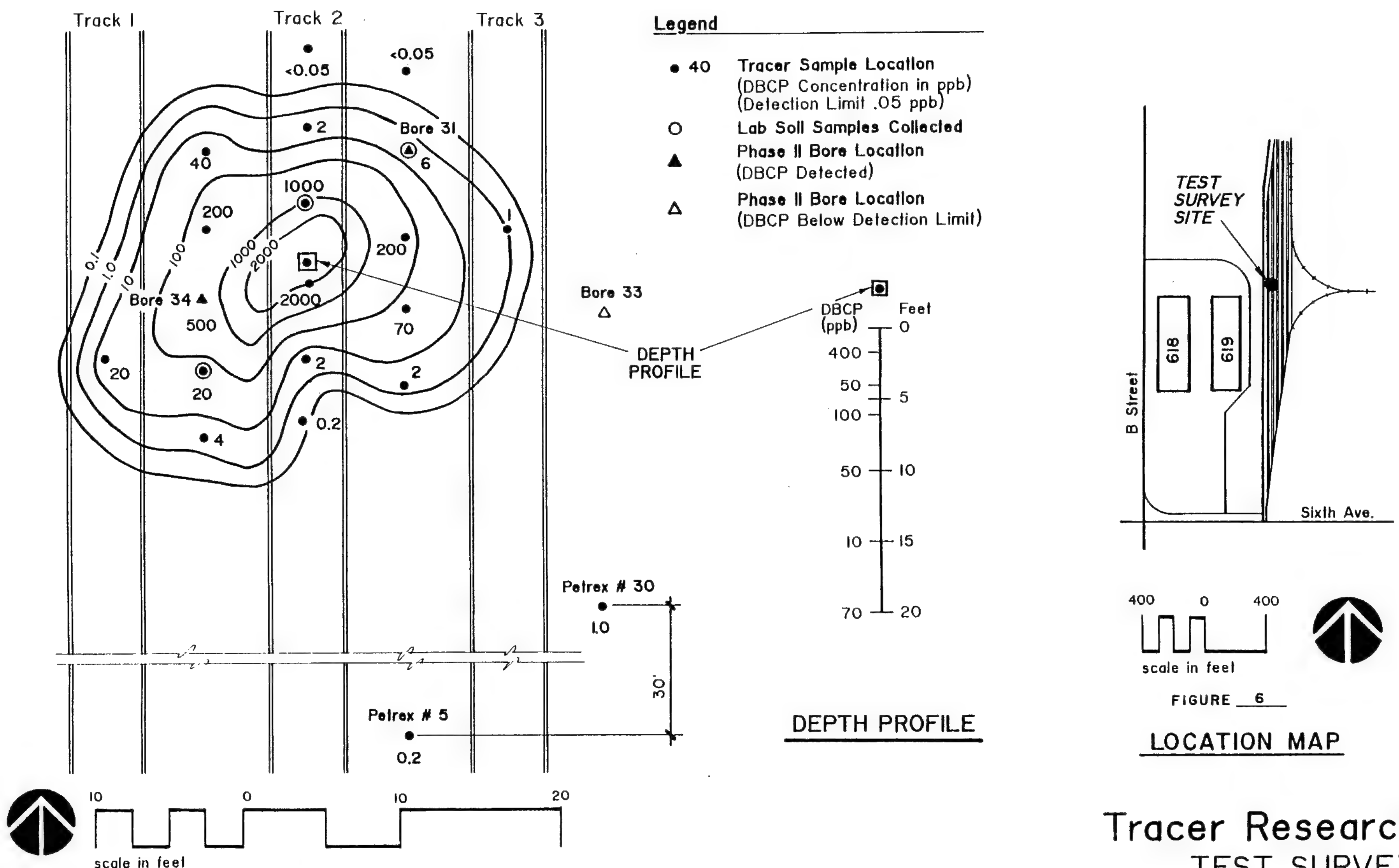


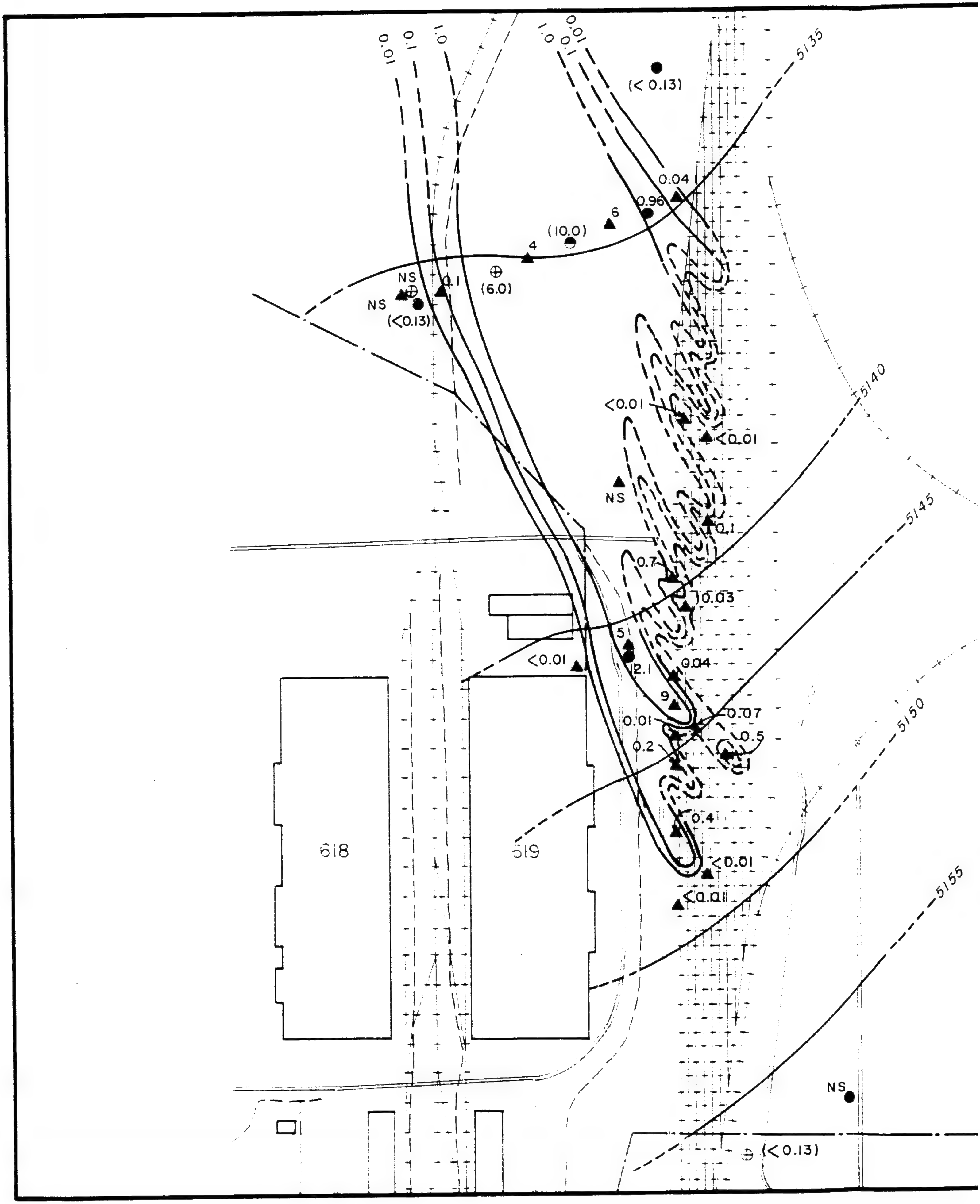
DBCP CONCENTRATION IN SOIL (1-2 Feet)

DEPTH PROFILE

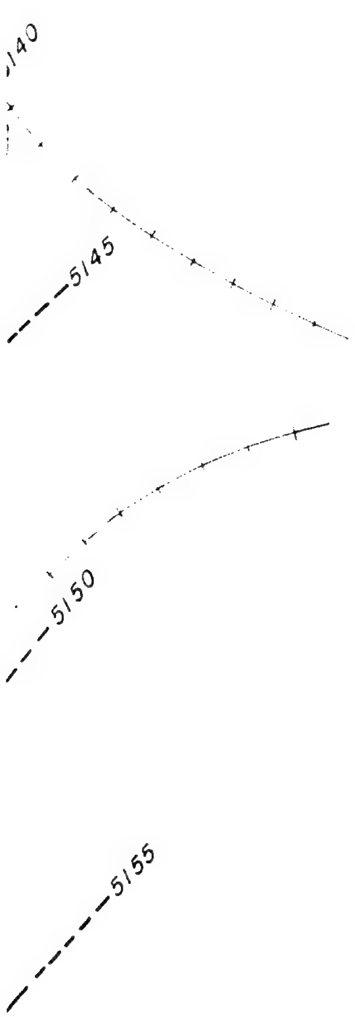
FIGURE 6

LOCATION MAP

Tracer Research
TEST SURVEY
Soil Extraction Samples



0.01
0.1
1.0
(< 0.13)
5135
0.04
0.96
6
(10.0)
4
NS
0.1
(6.0)
NS
(<0.13)
5140
<0.01
<0.01
NS
0.1
5145
0.7
0.03
5
<0.01
12.1
0.04
9
0.07
0.01
0.5
0.2
5150
0.4
618
519
<0.01
<0.01
5155
NS
(<0.13)



Legend

Symbol	Meaning
619	Building
	Road
	Railroad
	Sanitary Sewer
	Drainage
●	Previously Existing Alluvial Monitoring Well
⊕	Newly Installed Alluvial Monitoring Well
◓	Newly Installed Alluvial Cluster Well
▲	Cone Penetrometer Test Boring
	Concentration in Microgram Per Liter
⊕ (6.1)	DBCP, April 1989
● 0.96	DBCP, July 1989
NS	Not Sampled
5140	Contour of Water Table, July 1989

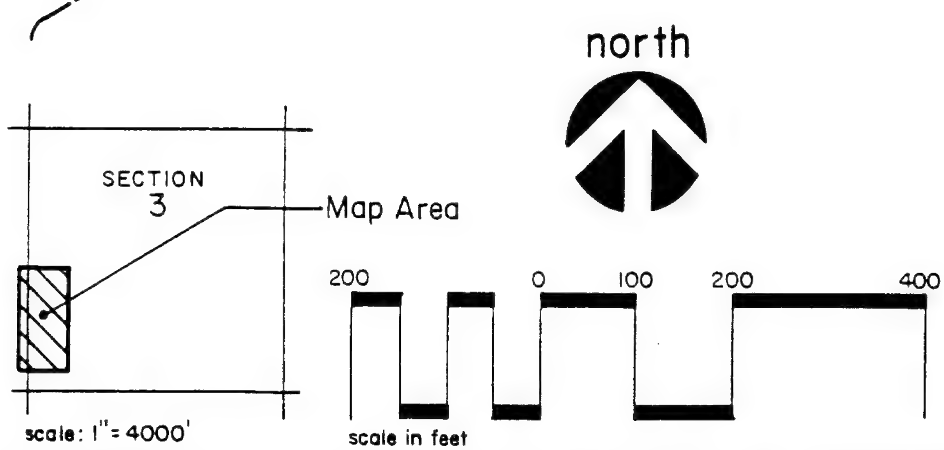


Figure: 7

Distribution of Dibromochloropropane in Groundwater, April and July 1989

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Survey Site), respectively. As noted above, lateral migration of residual or vapor-phase DBCP from the Test Survey Site toward CPT-12 and Well 03523 may have occurred along low permeability clayey sand and clay lenses.

The concentration of DBCP in groundwater consistently decreases with depth. This decrease in concentration with depth indicates that residual DBCP that contributes to groundwater contamination is either restricted to the uppermost portion of the alluvial aquifer or is located above the water table in overlying unsaturated sediments.

Residual DBCP located in the unsaturated zone would be transported to the water table either in the vapor-phase or in dissolved aqueous recharge, while residual DBCP located within the upper portion of the alluvial aquifer would be dissolved directly into groundwater. Either of the two mechanisms of transport through the unsaturated zone or dilution of dissolved DBCP could explain the low concentrations (relative to the aqueous solubility of DBCP) in alluvial groundwater beneath the railyard.

4.5 CONCLUSIONS

The technical approach used in this investigation was successful in characterizing the source area of the DBCP plume in the holding tracks of the Rail Classification Yard. Although a more detailed understanding of the site has been gained, additional investigations will be necessary to identify more precise sources of DBCP.

Results of this investigation indicate that the sources of DBCP to alluvial groundwater are unsaturated soils and sediments that contain residual DBCP from leaks from railcars previously located in the railyard. Based on results from a soil gas survey, the Test Survey Site is interpreted to be the primary surface expression of residual DBCP in soils and sediments that

is contaminating groundwater. Numerous smaller sites of soil contamination occur north of the Test Survey Site. They may also be surface expressions of residual DBCP that is contaminating the alluvial aquifer in lower concentrations than near the Test Survey Site. The pathways between sites of surface soil contamination and groundwater are probably intricate due to the complex stratigraphy and thick vadose zone in the railyard.

The highest concentrations of DBCP in groundwater near the railyard appear to be emanating from one area near CPT-12 to Well 03523. It has not been possible so far to determine whether surface contamination overlies this area or DBCP has migrated from the area of surface contamination near the Test Survey Site southwest along an impermeable zone toward CPT-12. If additional definition is necessary for remediation purposes, further investigation will be required.

5.0 TECHNOLOGY ALTERNATIVES

A variety of response actions in the railyard area can be concluded for meeting the stated objectives of this IRA (Figure 8). This section of the Alternatives Assessment discusses the alternative technologies that have been evaluated for implementation in the railyard area.

5.1 NO ACTION

The no action alternative would not involve the implementation of an interim remedial action. The existing Irondale Boundary System would continue to prevent migration of DBCP off the RMA. However, since there has been a trend toward increased seasonal off-post groundwater pumping, the no action alternative has been omitted from the technology alternatives screening and evaluation process.

5.2 GROUNDWATER INTERCEPTION/CONTAINMENT

Groundwater interception consists of the extraction and treatment of contaminated groundwater and the reinjection of the treated water to the aquifer. This alternative could isolate the sources and remediate the groundwater plume much closer to the source area than does the Irondale Boundary System.

Three basic types of groundwater intercept systems, with possible variations, may be effective in meeting the objectives of this IRA. All would incorporate a groundwater treatment facility (new or existing) as an integral component of the system. This facility would likely use granular carbon adsorption as the primary treatment process for the removal of DBCP from the extracted contaminated groundwater. Carbon adsorption is a proven technology and has been demonstrated to be very effective in the removal of organic contaminants from groundwater at several other locations on the RMA (North and Northwest Boundary Systems, and Irondale Boundary System).

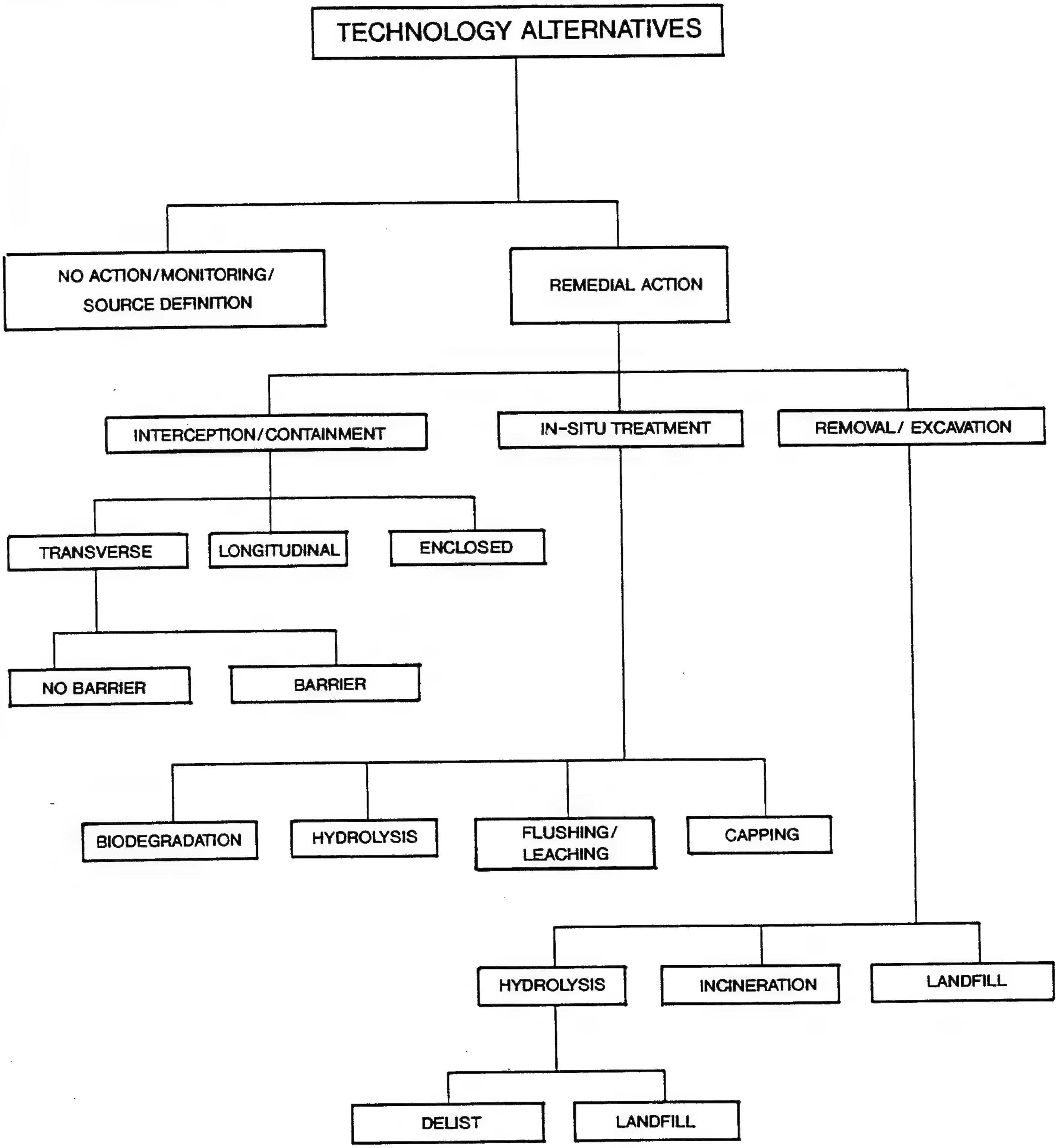

Figure: 8

TECHNOLOGY ALTERNATIVES FOR RAIL CLASSIFICATION YARD IRA

Prepared by:

MK-ENVIRONMENTAL SERVICES
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Because DBCP is the only contaminant of concern in the railyard area groundwater and is the only organic which must be removed, operating experience with the IBS demonstrates that carbon adsorption would be very effective in removing this compound at the relatively low concentrations present. Other possible treatment processes would require considerable laboratory treatability studies and pilot testing to demonstrate their feasibility and effectiveness. Consequently, the consideration and evaluation of other groundwater treatment processes is not necessary or consistent with timely execution of an IRA for the purposes of this Alternatives Assessment.

One type of intercept system that would be effective in meeting the objectives of this IRA would incorporate a groundwater recovery and recharge system oriented approximately perpendicular to the movement of regional groundwater flow and contaminant migration. The objective of this type of system would be to recover DBCP by extraction of contaminated groundwater and to prevent its migration by creating a hydraulic barrier just downgradient of the railyard. The Irondale and Northwest boundary systems are examples of this type of system. A row of recovery wells, coupled with a downgradient recharge system, would be configured to allow the establishment of a hydraulic barrier (reverse gradient) to the DBCP plume migration. Recirculation of treated water from the mound created by recharge would increase operational costs but the expense of installing a physical barrier is avoided. To reduce the cost of operation, a physical barrier between the recovery and recharge components of the system (such as a soil-bentonite slurry wall) could be incorporated into the design to prevent recirculation of treated water. The primary components of this type of system might include the following:

- One or more rows of recovery wells.

- One or more rows of recharge wells or, recharge trenches or leach fields.

- Pipelines to transport the pumped water to a treatment facility and then to the recharge system.

- A groundwater treatment facility utilizing carbon adsorption (excess capacity in the Irondale Boundary System treatment plant should be considered).

- If cost-effective, a physical barrier (e.g., a soil-bentonite slurry wall).

A second type of intercept system would incorporate similar components, but would be configured differently. One or more rows of recovery wells would be oriented along the longitudinal axis of the DBCP plume with recharge components located just beyond both outer limits of the plume. A reverse gradient or a physical barrier would not be required for this type of system. The objective of this system would also be to recover DBCP by extraction of the contaminated groundwater and to prevent DBCP migration by recovery of the plume. Recirculation of treated water would still occur with this type of system, but to a lesser extent. Consequently, operational costs could be significantly reduced.

The third type of intercept system considered for this IRA consists of a physical barrier, such as a soil-bentonite slurry wall encircling the DBCP source areas. Contaminated groundwater would be pumped from inside the enclosure and treated water would be reinjected outside (also inside if desired for flushing) of the enclosure. The inflow into the system would be a small quantity of leakage inward through the slurry wall and local surface recharge. Therefore, the long-term rate of pumpage and treatment would only have to equal the amount of inflow to the system, and operational costs could be reduced. However, the cost of slurry wall construction at this depth (greater than 100 feet in some areas) to enclose the source area

would be significant. Consequently, accurate plume and source area delineation would be needed to ensure containment of the DBCP.

There are several advantages to the installation of a groundwater intercept system near the source area. DBCP could be recovered much closer to the suspected source area. Consequently, regional and local changes in hydrogeologic flow regimes and off-post groundwater pumping rates that could impact the current plume pathway and operation of the IBS would have minimal impacts on the effective operation of this intercept system. The exact location and extent of the DBCP sources would not need to be defined thus accelerating the implementation of an IRA.

5.3 IN-SITU REMEDIATION

5.3.1 In-situ Biodegradation

In-situ biodegradation involves microbial degradation of organic contaminants by altering environmental conditions to enhance bacterial degradation of the compounds. This generally results in the breakdown of these organics to non-toxic or less toxic compounds. Several types of in-situ biodegradation technologies have been used in hazardous waste applications, but the most well-developed and feasible method for this application involves the optimization of aerobic (oxygen-requiring) microbial processes. In this technique oxygen (or peroxide) and nutrients, such as nitrogen and phosphorus, must be delivered to the subsurface zone of contamination through injection wells or some type of infiltration system to enhance environmental conditions for microbial degradation. Indigenous bacteria, or specially adapted or genetically altered microbes, can be used to degrade a wide range of organic compounds if sufficient oxygen and nutrients are provided.

The biodegradability of DBCP, site hydrogeology, and other environmental factors (such as oxygen and nutrient supply) that affect microbial activity all influence the feasibility of in-situ biodegradation. Laboratory studies have indicated that DBCP can be dehalogenated by microbes (Arthur D. Little, Inc., 1981) however, other studies have produced inconclusive results.

In-situ biodegradation of DBCP would require knowledge of the areal and vertical extent of the DBCP source areas. In addition, the site hydrogeology must be better defined in order to assess the feasibility of distributing the required oxygen and nutrients in the zone of contamination. To date, this information is not available and considerable additional knowledge of the site and source characteristics would be required. An effective monitoring network would also have to be incorporated into the system to validate the degradation of DBCP. Basic microbial investigations, laboratory treatability studies, and a field test program, would need to be implemented to determine the feasibility and effectiveness of this technology and to optimize the process. These investigations would be time consuming and would delay implementation of an IRA.

5.3.2 In-situ Hydrolysis

Another in-situ technology that may be applicable to this site is the use of hydrolysis to chemically degrade DBCP into a non-toxic product (2-bromoallyl alcohol). Hydrolysis involves the chemical reaction of a compound with water and is one of the most common reactions resulting in the degradation of chemicals in the environment. Studies have shown that the hydrolysis rate of DBCP is dependent on the pH of the solution and reaction temperature. More basic solutions, as well as higher temperatures, result in more rapid degradation of the compound. The half-life for DBCP in pH 9 buffer solution at 35 degrees Celsius is about 32 days, whereas the half-life at 25 degrees Celsius is approximately 152 days (Shell, 1982).

To make in-situ hydrolysis of DBCP in the railyard area feasible, artificially raising the soil solution pH and temperature would be required. If any DBCP source areas are located in the unsaturated zone, water would have to be provided through a series of injection wells or some type of recharge trench or leach field. This water would be treated with soda ash or caustic to raise the pH of the groundwater, and heated to optimize the temperature for the hydrolysis reaction. A containment system would be required to collect the groundwater and to isolate the source and hydrolysis area. Treatment and upgradient reinjection of the water would probably be required. A monitoring network would be required to validate the degradation of DBCP. Laboratory treatability studies, as well as a field pilot program, would need to be implemented to determine the feasibility and effectiveness of this technology and to optimize the process.

The source area and site hydrogeology would need to be well-defined for successfully treating the source of the DBCP plume by means of controlled hydrolysis. Hydrogeologic control of the treated and injected water may be difficult. Again, laboratory treatability studies and a field test program would have to be implemented. These studies are time-consuming, thereby delaying implementation of an IRA. If feasible, the continuous release of DBCP to the groundwater could be significantly reduced utilizing hydrolysis.

5.3.3 In-situ Flushing/Leaching

Soil flushing or leaching involves injecting or infiltrating water or an aqueous solution into the zone of contamination and collecting the contaminated eluates for removal, recirculation, or on-site treatment and reinjection. Contaminants sorbed to soil particles would be partially mobilized into solution during elution due to solubility, formation of an emulsion, or by reacting chemically with the leaching solution. Solutions with

the greatest potential for soil flushing applications include water, acids and bases, complexing and chelating agents, surfactants, and certain reducing agents.

The log octanol/water partition coefficient for DBCP is estimated to be from 2.57 to 3.09 (Shell, 1982). This indicates that DBCP is fairly soluble in water and that injected water might be an effective flushing solution. Surfactants may also be used in the solution to improve the solvent property of the injection water and to enhance the removal of DBCP. Surfactants may improve the effectiveness of DBCP removal by improving both the detergency of the aqueous solution and the efficiency by which organics may be transported by the solution. A downgradient groundwater recovery system would be needed to capture the leachate. The leachate would then be treated for the removal of DBCP (using carbon adsorption), and reinjected or reapplied, possibly upgradient, to the contaminated source area in the unsaturated zone. A monitoring network would be required to evaluate the performance of the system. In addition, the injection of water treated to raise its pH and temperature to optimize the hydrolysis of DBCP while simultaneously flushing or leaching the compound from the soil may be desirable. The combination of mobilization and degradation of DBCP through in-situ flushing and hydrolysis could prove very effective in remediating the source area.

Flushing/leaching/hydrolysis could be advantageous in the DBCP source area because the aqueous solution applied to the soil surface may percolate downward through the unsaturated zone following the natural and historical pathway of DBCP migration to the aquifer. This scenario could be very effective in removing DBCP currently adsorbed to the soil particles in the unsaturated zone.

The areal extent of the DBCP source areas must be well-defined in order for this technology to be feasible. Laboratory studies would be required to determine the leachability of the compound, and a field test program would need to be implemented to determine the feasibility and effectiveness of this technology and to optimize the process. Again, these studies would be time-consuming thereby delaying implementation of an IRA.

5.4 CAPPING

Capping is used to cover subsurface waste materials and contaminant sources to prevent their contact with infiltrating precipitation and groundwater. This technology may be applicable to the Rail Classification Area IRA for DBCP in the unsaturated zone. Capping could reduce the mobility and migration rates of DBCP in the unsaturated zone. Desirable characteristics of caps include multi-layered design, minimum cover maintenance requirements, low liquid movement through the wastes, effective site drainage, maximum resistance to damage by settling or subsidence, and a permeability less than the underlying liner or soils. Groundwater monitoring wells should be used in conjunction with the cap to detect any unexpected contaminant migration. Surface water control structures such as ditches, dikes, and/or berms, should also be used to collect precipitation drainage from the cap. Grading and revegetation should also be incorporated into multi-layered caps.

Caps require long-term maintenance and must be periodically inspected for settlement, erosion, ponding of liquids, and naturally occurring invasion by deep-rooted vegetation. The effectiveness of caps is variable because of the variety of synthetic liner materials, limited availability of natural and admixed liner materials, and the difficulty of defining the rate of contaminant migration resulting from infiltrating precipitation. When a synthetic liner is supported by a low-permeability base, the underlying wastes are unsaturated, the

saturated zone is a good distance from the zone of contamination, and correct maintenance procedures are implemented, the effectiveness of the cap will be optimized.

5.5 EXCAVATION AND TREATMENT

Removal or excavation of contaminated materials is another technology alternative for the railyard. This technology involves the removal of soils containing the source of DBCP using heavy machinery such as a backhoe or dragline. Excavation followed by land disposal or some type of onsite treatment are common technologies applied in hazardous-waste site remediation.

In order for excavation to be feasible, the approximate areal and vertical extent of the DBCP source areas must be carefully defined. One approach to removal would be to obtain a detailed definition of the source area so that the contaminated material could be entirely removed with the minimum amount of excavation. An alternate approach would be to excavate an area extending far enough outside of the area of all known "hits" to ensure removal of all contaminated material. In either case, a recovery or intercept system immediately downgradient may be required in case any DBCP is not removed and continues to contaminate the aquifer. A monitoring network would also be required. If the location and extent of the DBCP source area can be defined, this technology may provide a permanent and relatively quick remedy.

Excavation may become cost-prohibitive if the depth or areal extent of contamination is excessive. Consequently, if the source areas are found to be located at a significant depth (possibly in the saturated zone) or over a widespread area, then this technology may not be cost-effective. Once the material is removed, it must be either: 1) treated and disposed of (onsite or offsite); 2) temporarily stored and treated and/or disposed of later; or 3) disposed of (onsite or offsite). Laboratory treatability studies and a field pilot program would

also need to be implemented to determine suitable technology for treating the excavated soils. Consequently, implementing this alternative in a timely manner may not be possible.

5.5.1 Hydrolysis

If excavation of the contaminated soil were feasible, hydrolysis of DBCP within the soil to chemically degrade the compound into a non-toxic product (2-bromoallyl alcohol) may be performed by treating the excavated material in tanks above ground. The excavated soil could be screened to remove the larger particles (sands and gravels) which probably adsorb very little DBCP. Water that has been treated to raise its pH and temperature (to optimize the hydrolysis of the compound) would then be added to the remaining finer soil particles to create a slurry. Agitation of the slurry in some type of batch reactor (about 50 tons/batch) for a period of time could be all that is required to hydrolyze the compound. The slurry could then be dewatered, leaving the decontaminated soils.

When testing of each batch of dewatered material demonstrates that DBCP has been effectively removed, the treated soil may be delisted, backfilled into the original trench, and compacted. If the material could not be delisted, it would have to be disposed of either onsite or offsite, or retreated.

Hydrolysis of DBCP in full scale situations has not been demonstrated and would require laboratory treatability studies and field testing to determine the optimum temperature and pH for application on this site. These studies would be time consuming thereby delaying implementation of an IRA.

5.5.2 Incineration

Incineration is a treatment technology for solids, liquids, and gases that uses high temperature oxidation under controlled conditions to degrade a substance into products that usually

include CO_2, NO_x, HCl gases and ash. The toxic byproducts of incineration such as particulates, SO_2, NO_x, HCl, and incomplete combustion products require air pollution control equipment to control their release to the atmosphere. The most common incineration technologies used in hazardous waste applications include liquid injection, multiple hearth, fluidized bed, and rotary kiln.

Because of their ability to burn wastes in any physical form and their high incineration efficiency, rotary kilns are the generally preferred method for treating mixed hazardous solid wastes. They can incinerate solids and liquids independently or in combination and can take wastes without any preparation.

Rotary kilns have a high capital cost and incineration has a relatively high operational cost. Air pollution control equipment and monitoring would be required to ensure compliance with air quality regulations.

6.0 ALTERNATIVES SCREENING AND EVALUATION

The alternatives discussed in Section 5.0 of this report have been evaluated based on their relative ability to meet the objectives of this IRA and the assessment criteria listed in Section 3.0. These evaluations are summarized in this section of the assessment.

6.1 NO ACTION ALTERNATIVE

As discussed previously, the no action alternative is not selected as a preferred IRA alternative because of its inability to meet the stated objectives.

6.2 GROUNDWATER INTERCEPTION ALTERNATIVES

Groundwater interception systems have proven to be very effective in preventing the migration of organic contaminants in groundwater on the RMA, and specifically DBCP at low (ppb) concentrations. They have the additional advantages of being rapidly implementable and relatively cost-effective.

Since a groundwater intercept system can successfully operate when installed anywhere downgradient of the DBCP sources, it is not crucial that the DBCP source boundaries be located precisely. In this IRA this advantage is significant, since precise determination of the DBCP source locations has not been accomplished and is a potentially lengthy process. Another significant advantage of groundwater intercept systems is that they would not only be compatible with any final remediation of the site, but also might prove to be a necessary part of any final remediation. For example, if one of the in-situ or excavation based treatment processes were selected for implementation either under this IRA or as a final remedy, a groundwater intercept system will most likely be required.

6.3 IN-SITU REMEDIATION ALTERNATIVES

In-situ remediation alternatives appear to be promising for final remediation of the DBCP contamination in the railyard area. One of the advantages of an in-situ treatment alternative is that the sources of DBCP contamination in the aquifer would be eliminated, thus reducing the time span for site management.

There are, however, disadvantages of selecting in-situ remediation alternatives for implementation under this IRA. One disadvantage is that the effectiveness of in-situ treatment is generally variable over a site. Probably the most obvious disadvantage is that timely implementation of a successful in-situ remediation alternative seems unlikely. Extensive investigations of the site hydrogeology and contamination would be required before any in-situ remediation alternative could be successful and cost-effective. In addition, extensive studies, testing, and optimization would be required in order to select a treatment alternative and to determine how it should be implemented. In any case, it is likely that a groundwater intercept system would also be required in conjunction with an in-situ treatment alternative. The intercept system would prevent migration of DBCP (and possibly other chemicals that may be mobilized as a result of in-situ treatment processes) during the treatment process.

6.4 CAPPING

Capping would have the effect of reducing the rate at which DBCP is leached from unsaturated soils beneath the railyard. It would not totally eliminate DBCP migration, nor would it eliminate the DBCP plume sources. Capping would have no significant effect on DBCP that may already be in the groundwater beneath the site. Because of its uncertain and limited effectiveness in preventing the spread and migration of DBCP, it should only be considered in conjunction with other technologies.

6.5 EXCAVATION AND TREATMENT

Some of the advantages and disadvantages of excavation and treatment of the DBCP beneath the railyard area are very similar to those discussed for in-situ processes. If successfully implemented, it has the significant advantage of eliminating the sources of DBCP in the groundwater plume.

Because of the volume and depth of soils that may be acting as sources of DBCP, the excavation and treatment alternative has the notable disadvantage of not being effective at this time. Extensive investigations would first be required to accurately define the extent of the DBCP sources so that excavation and treatment can be implemented effectively. These investigations could not be accomplished quickly. As with the in-situ treatment alternatives, the installation of a groundwater intercept system would be necessary in conjunction with excavation.

7.0 SELECTION OF PREFERRED ALTERNATIVE

Alternatives which may be applicable to this site appear to exist within each of the three remedial options considered, i.e., containment, in-situ treatment and removal/treatment. It is expected that attenuation of DBCP concentrations downgradient of the source areas would commence with implementation of an alternative, thereby mitigating possible impact on the plume's flow direction caused by off-post pumping. Also, over time, contaminant loading on the IBCS would decrease, allowing eventual shutdown of that system (if operation is not required by other contaminants). The time required to flush the downgradient aquifer cannot be forecast with any exactitude. However, it is known that groundwater velocity within the contaminated plume is relatively high (2-4 ft/day). Rapid response of the plume's concentration profile to seasonal changes in groundwater flow has been regularly observed since plume monitoring first began. Also, the physical properties of DBCP are conducive to reasonably high mobility in groundwater. These factors justify expectation of attenuation of DBCP concentration downgradient of the source area in a reasonable period of time.

Containment alternatives based on groundwater interception utilizing either the longitudinal or transverse recovery well configuration coupled with activated carbon absorption for removal of DBCP and reinjection of treated groundwater, best meet the object and selection criteria for this IRA. All of the technology elements, i.e., groundwater interception and injection and activated carbon absorbtion treatment are highly effective for low concentrations of DBCP in groundwater as demonstrated by the three operating boundary control systems at the RMA. No further studies of site characteristics or treatment investigations for feasibility/effectiveness are required to proceed with implementation. Thus, the containment alternative provides the most timely response of the alternatives studied. The containment alternative also would be

most consistent with possible remedies in the final ROD. As discussed, an intercept system immediately downgradient of the source area would most likely be a component of a treatment/removal action or even itself constitute the final remedy.

To be effective, the alternatives considered in Section 6.0, other than the two containment alternates discussed above, all require definition of the boundaries of the primary source(s) of the DBCP contaminant plume. For several years, Shell and the Army have expanded considerable efforts toward defining the primary source(s) with only limited success. Most recent investigations indicate that the soil pathway(s) to groundwater may be complex. Therefore, considerable time surely would be consumed in defining site boundaries, with the possibility even that a satisfactory definition cannot be achieved. In addition, a need for treatability studies to determine feasibility and effectiveness is indicated for the treatment alternatives considered. Such studies would also consume time. These alternatives thus do not meet the implementability criteria, including timeliness, and therefore none is proposed for the preferred alternative.

8.0 DATA GAPS

The investigation of the hydrogeology, water quality and source areas, performed to date have been targeted at the acquisition of data suitable for use in developing the Alternatives Assessment and Decision Documents. The data collected has been judged to be suitable for this purpose, however, data gaps will exist when detailed engineering of the selected alternative is started during the preparation of the Implementation Document.

If all three types of intercept systems are evaluated as part of the Decision Document phase of this IRA, then source definition investigations may be continued to define the location and extent of the DBCP source area. This definition is necessary to evaluate the location and length of a slurry wall required for the enclosed type of intercept system to enclose the DBCP source area.

The collection of other data, such as additional hydraulic conductivity values for refined flowrate estimates, lithology and width of the plume at the location of the intercept system, and water quality at the location of the extraction wells are not essential until the design of the intercept system is started during the preparation of the Implementation Document.

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APPENDIX A

Site Characterization Field Methods and Results

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APPENDIX A

SITE CHARACTERIZATION - FIELD METHODS AND RESULTS

1.0 FIELD METHODS

1.1 DRILLING AND WELL INSTALLATION

In March 1989, five new alluvial wells were installed in the railyard area (Text Figure 3). Four wells are located downgradient, while one is upgradient. Two of the four downgradient wells comprise a paired cluster well installed to monitor the vertical distribution of DBCP in the alluvial aquifer. Well construction details are provided in Table A-1.

Prior to installing the wells, boreholes were drilled to bedrock using a 10-5/8 inch O.D. hollow-stem auger. A split-spoon sampling device was used to collect samples every 5 feet. A geologist described and recorded the lithology. The borehole logs are included as Appendix B.

After completion of the boreholes, four of the wells (03501 through 03504) were installed using 4-inch threaded PVC casing and either a 10- or 20-foot, 0.02-inch slot PVC screen. Well 03505 was installed as an injection well for an aquifer test, and a 40-foot, 0.03-inch slot PVC screen was used. Wells 03504 and 03505 were screened over the entire saturated thickness. Well 03501 was screened over the upper 20 feet of saturated alluvium. Wells 03502 and 03503 are a pair of cluster wells with Well 03502 screened over the bottom 10 feet of the aquifer and Well 03503 screened over the upper 20 feet. Well construction diagrams are included with the borehole logs in Appendix B.

TABLE A-1 MONITORING WELL CONSTRUCTION DETAILS

Well ID	Surface Elevation (ft msl)	Total Depth Drilled (ft)	Depth to Bedrock (ft)	Depth to Groundwater (ft from surface)	Screen Interval (ft)
03501	5210.27	113.3	112.5	74.7	68.5 - 88.5
03502	5208.62	111.2	109.5	73.5	101.2 - 111.2
03503	5208.58	90.0	*	73.4	70.0 - 90.0
03504	5210.82	68.2	68.2	54.1	48.2 - 68.2
03505	5203.43	106.6	107.0	67.6	65.6 - 105.6

Note: All well locations have been surveyed. See Appendix A for field borehole log sheets.

*Well 03503 is a cluster well and has approximately the same bedrock depth as Well 03502.

Sand pack (10/20 sand in the monitoring wells and 8/12 sand in Well 03505) was placed from the bottom of each borehole to approximately 2 feet above the top of each screen. A 1- to 2-foot thick bentonite seal was positioned above the sand, and grout was installed from the seal to within 3 to 10 feet of the ground surface. When the grout had settled, the holes were filled with concrete, and 6-inch diameter steel protective casing was installed. The wells were developed using standard surge and bail methods.

1.2 GROUNDWATER SAMPLING AND ANALYSIS

In April 1989, one groundwater sample was collected from each of the four new monitoring wells and two existing wells (03001 and 03010). Additionally, one duplicate sample from Well 03503 and one rinse blank were prepared to monitor the effect of sampling procedures on the analytical data.

Prior to sampling, static water levels were measured and well volumes calculated. Sampling procedures followed standard EPA guidelines and included purging three casing volumes from each well using either a 2-inch diameter stainless steel bailer or a stainless steel submersible pump. The bailer, equipped with a bottom emptying device, was used to collect three 40-ml glass vials for each sample.

The samples, blank, and duplicate were sent to a contract laboratory and analyzed for DBCP using USATHAMA-certified GC methods. All lab QC data were reviewed by USATHAMA, while all field QC data were reviewed by MK-Environmental Services to verify the quality of the data.

Two wells located in the railyard area (03009 and 03523) are routinely sampled in the Irondale quarterly monitoring program. These samples were analyzed by the same USATHAMA-certified laboratory. The water quality data from these wells are included in this site characterization.

1.3 AQUIFER TEST

In April 1989, after the completion of sampling, an injection test was performed in Well 03505 to estimate the hydraulic conductivity of the alluvial aquifer. This well was installed outside of the plume boundary to prevent additional spreading of the plume. A constant flow rate of 30 gallons per minute (gpm) of potable water was injected into the well for a period of nine hours, and the groundwater levels in Well 03010 (17 feet from the injection well) and Well 03501 (149 feet from the injection well) were measured at specified time intervals. Time versus water level rise curves were constructed for the two observation wells and hydraulic conductivities were computed using standard methodologies based on these curves.

1.4 SOIL GAS INVESTIGATION

1.4.1 Soil Gas Test Survey

In February 1989, Tracer Research Corporation of Tucson, Arizona conducted a test survey to determine the usefulness of soil gas technology for delineating the areal extent of DBCP contamination in shallow soil in the railyard. The test survey was conducted in an area of known contamination, which had been located by two Phase II Army borings in the tracks in the railyard. The methods and results were described in the Supplemental Letter Technical Plan (Shell, 1989). The test survey was successful, and a complete soil gas survey of the railyard was proposed.

1.4.2 Railyard Soil Gas Survey

In June 1989, an extensive shallow soil investigation of the railyard was conducted by Tracer Research Corporation (Text Figure 3). To evaluate environmental changes in temperature and soil moisture content between the test survey in February 1989

and the railyard survey in June 1989, soil gas and soil extraction samples were collected at a similar location within the test survey site. The June soil gas concentration was lower, but within one order of magnitude of the February sample. Some of the change may be accounted for by slightly different sampling locations. Since the June concentration was 5 orders of magnitude above the detection limit, the soil gas method was deemed acceptable, and the survey proceeded.

A sampling grid was designed to locate areas of soil contamination similar in size to the area delineated in the test survey (Text Figure 3). A total of 289 soil gas samples were collected at grid stations. A total of 53 soil extraction samples were collected in areas where the soil was saturated preventing gas sampling and in areas around soil gas detections where detailed investigations were conducted. Additionally, five soil samples were collected in the drainage ditch between the tracks and Building 619 in low areas opposite or downstream from 3 track drainage culverts.

Soil gas samples were collected by driving a steam cleaned steel probe to a 1.5 foot depth using a detachable aluminum driving point. The probe was then withdrawn 1 to 2 inches and soil gas was drawn through the probe using a vacuum pump. Three to five probe volumes of soil gas were evacuated before the sample was collected. A clean glass syringe was used to withdraw the sample from the probe.

Soil extraction samples were collected by detaching the drive point from the probe at approximately 1.5 feet and compacting soil into the open end of the probe to the sample depth of 2 feet. The probe was withdrawn from the hole, and a portion of the soil sample was removed and placed in a 40-ml glass vial.

1.4.3 Analytical Methods and QA/QC Data

Soil gas samples were analyzed by injecting aliquots of the soil gas samples into the gas chromatograph equipped with a Varian electron capture detector. The method was calibrated by injecting a fresh standard of DBCP in hexane.

Soil extraction samples were prepared for analysis by weighing the soil sample to the nearest 0.1 g and adding 2 to 20 ml of hexane depending on the amount of soil and/or DBCP in the sample. A volume of 2 microliters of the hexane extract was then injected into the gas chromatograph. The method was calibrated by injecting a fresh standard of DBCP in hexane.

DBCP standards were analyzed after every fifth sample; nitrogen and hexane blanks were frequently analyzed to determine if the sampling and analytical equipment contained residual contamination. Also, ambient air samples were analyzed during soil gas sampling to evaluate site conditions. A QA field audit was performed by MK-Environmental Services to verify that Tracer's QC procedures were followed.

1.5 CONE PENETROMETER INVESTIGATION

1.5.1 Cone Penetrometer Testing and Groundwater Sampling

In June and July 1989, lithologic, hydraulic, and water quality data were collected by Terra Technologies of Houston, Texas using cone penetrometer testing (CPT) methods (Table A-2 and Appendix C). The CPT survey was conducted to gather additional information on the vertical stratigraphy and vertical and lateral distribution of DBCP, and to determine the hydraulic conductivity of the alluvial aquifer. One CPT hole was located adjacent to Well 03505 (injection test well) for correlation of lithologies and hydraulic conductivity data.

TABLE A-2 CONE PENETRATION TEST DATA, JULY 1989

CPT ID	Surface Elevation (ft msl)	Total Depth Penetrated (ft)	Depth to Bedrock (ft)	Depth to Groundwater (ft)	Sample Depth (m)	Sample Depth (ft)	Sample Type
CPT-1	5210.18	83.3	83.3	61.4	21.4	70.2	W/B
CPT-2	5204.78	83.8	NDE	64.3*	19.95	65.5	W
					24.2	79.4	W
CPT-3	5209.34	84.2	NDE.	70.4	24.3	79.7	W/B
CPT-4	5209.12	103.5	103.5	71.8	25.0	82.0	W/B
CPT-5	5208.47	106.6	106.6	70.7	NS		--
CPT-6	5209.85	90.2	NDE	69.4	23.7	77.8	W/B
CPT-7	5209.84	91.4	89.5	64.7	17.55	57.6	G
					20.35	66.8	W
					24.0	78.7	W
					25.8	84.6	W
CPT-8	5206.28	86.5	NDE	64.5*	20.4	66.9	W
CPT-9	5202.9	105.6	105.6	66.2*	NS		--
CPT-10	5210.11	89.7	85.9	62.5	19.0	62.3	G
					19.6	64.3	W
					21.8	71.5	W
					23.8	78.1	W
					26.0	85.3	W
CPT-11	5209.57	95.6	88.6	65.3*	20.5	67.3	W
					26.0	85.3	W
CPT-12	5209.47	90.9	89.5	66.0	20.6	67.5	W
					26.5	86.9	W
CPT-13	5209.04	105.0	100.7	68.1*	22.5	73.8	W
					27.8	91.2	W
CPT-14	5208.04	89.7	NDE	73.1	23.0	75.3	W
					25.2	82.6	W
CPT-15	5208.21	86.1	NDE	73.6	23.8	78.2	W/B
CPT-16	5209.28	78.4	NDE	74.5*	23.9	78.3	W/B
CPT-17	5205.38	109.7	109.1	70.4	23.1	75.7	W/B
					28.1	92.3	W/B

08/17/89

CPT ID	Surface Elevation (ft msl)	Total Depth Penetrated (ft)	Depth to Bedrock (ft)	Depth to Groundwater (ft)	Sample Depth (m)	Sample Depth (ft)	Sample Type
CPT-18	5209.34	100.5	93.5	66.4	21.0	68.7	W
					26.0	85.4	W
CPT-19	5210.11	90.0	87.0	64.2*	21.1	69.2	W
					23.7	77.8	W
CPT-20	5210.44	81.3	NDE	63.5	21.1	69.2	W
					23.0	75.4	W
C-3	5209.38	81.4	NDE	71.9*	24.8	81.4	W/B
C-4	5211.10	73.1	NDE	64.3*	22.3	73.1	W/B

Note: All CPT locations have been surveyed. See Appendix B for CPT logs.

Explanation

NDE = Not Deep Enough
NS = Not Sampled
W = Groundwater
W/B = Groundwater/Bailed
G = Soil Gas
*Approximate Depth to Groundwater

CPT holes were installed in 22 locations (Text Figure 3); lithology profiles were obtained at 20 of the locations. Groundwater samples were collected from one to four sampling depths at 20 of the 22 locations, depending on lithology, saturated thickness, and sampling method. Where possible, one sample was collected within 2 feet of the top of the alluvial aquifer and one within 2 feet of the bottom of the alluvial aquifer.

The CPT holes were installed using standard methods as described in Shell (1989). In the standard CPT groundwater sampling procedure, an evacuated 35-ml sample tube is lowered inside the sampling rods to the sample depth, filled with groundwater by differential pressure, and raised to the surface. Typically 10 to 25 ml would be collected during each attempt, depending on permeability of the aquifer and the duration of sampling. The collected water was transferred from the CPT tube to a 40-ml VOA vial. Collection was repeated until the VOA vial was filled and no headspace existed.

The groundwater sampling procedure was modified at eight locations because dense lithologies prevented use of the standard sampling equipment. In the modified procedure, a water-tight removable stainless steel tip was attached to the CPT rods, which were hydraulically driven to approximately 10 feet below the water table. The rods were raised 2 inches, disengaging the tip and allowing groundwater to enter the steel rods. A small-diameter stainless steel bailer was used to sample the groundwater inside the rods. Because of a large amount of sediment in the samples compared to those obtained using he standard CPT collection technique, both unfiltered and filtered (0.45 micron filter) samples were collected to compare the effects of fine sediments in the sample obtained using this method. All samples were collected in 40-ml glass vials with no headspace and chilled to 4°C until they were analyzed.

Also, a few samples were collected to compare headspace analysis with EPA Method 504. Because of rigorous calibration requirements for different methods, this test was also discontinued.

Soil gas sampling using CPT methods was attempted at the soil gas test survey site. Samples were collected at the same location and depths where DBCP had been detected in soil gas and soil samples. No DBCP was detected in the CPT samples. This was probably due to the lower volume of soil gas collected using CPT methods versus standard Tracer soil gas methods. Due to the limitations of collecting larger samples using the CPT methods, soil gas sampling using CPT methods was not utilized at this site.

1.5.2 Analytical Methods and QA/QC Data

Real-time analyses of groundwater samples were conducted to provide immediate data used to direct the field program. The samples were analyzed onsite by Tracer Research by using EPA Method 504 for DBCP.

To monitor the reliability of the onsite laboratory data, two check standards were prepared by a USATHAMA-certified laboratory and analyzed by Tracer Research. In addition, three split samples were analyzed both by Tracer Research and a USATHAMA-certified laboratory.

2.0 RESULTS

2.1 SITE GEOLOGY

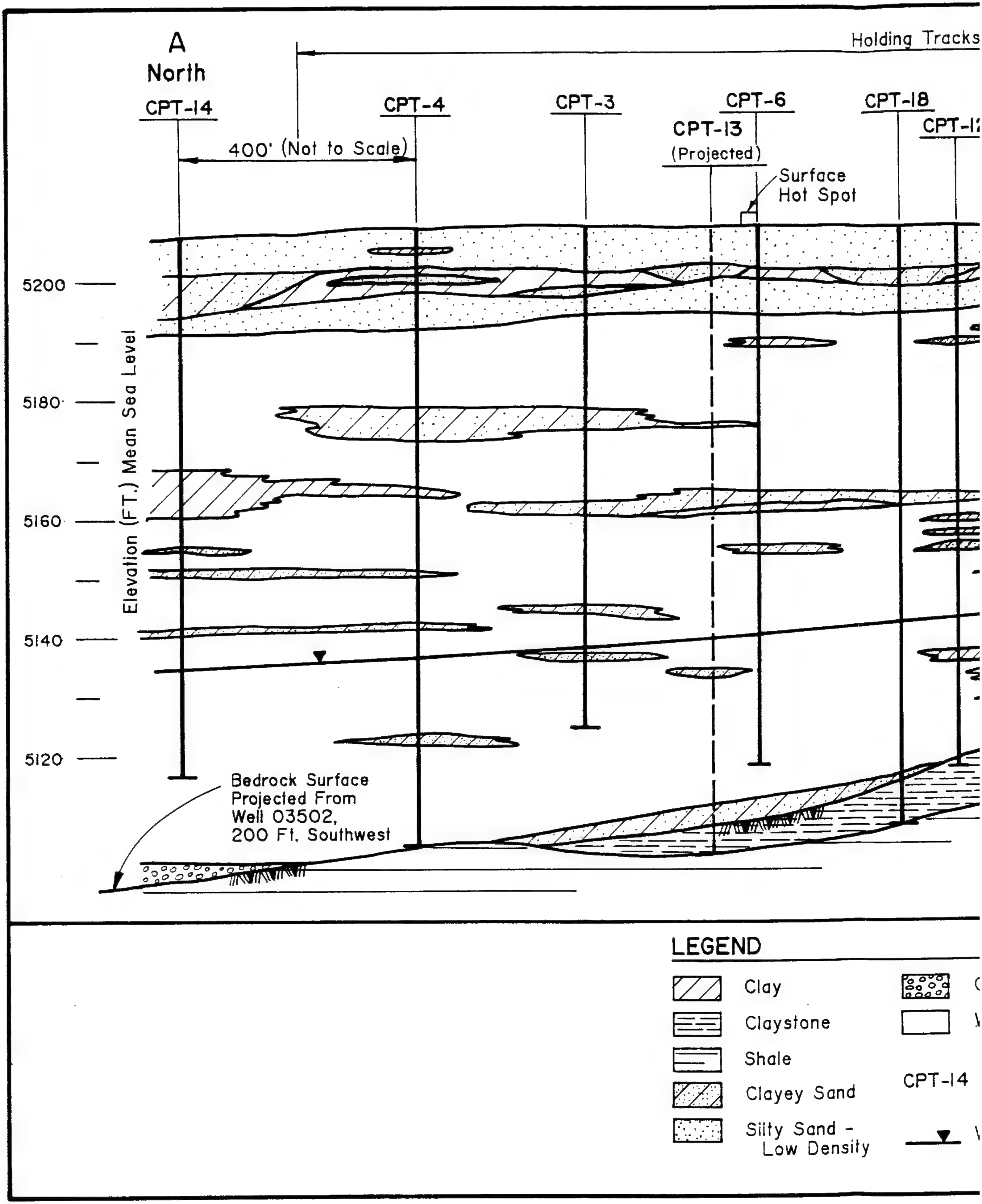
Regional hydrogeologic conditions at the RMA have been discussed in detail in previous reports (May, 1982; MKE 1987; Ebasco, 1989) and are not repeated here. The two pertinent stratigraphic units underlying the railyard are the Quaternary Alluvium and Denver Formation. The alluvium thickens from 65 to 110 feet from south to north and is composed primarily of coarse-grained sand. The sand varies from poorly graded to well graded and frequently contains gravel (Figure A-1 and Appendices B and C).

The units within the alluvium from ground surface to the Denver Formation are interpreted to be: eolian, Broadway, Louviers, and channel fill (MKE, 1987). A low-density silty sand is present in the upper 10 to 20 feet and is interpreted as eolian. Within the eolian sediments, widespread thin, interbedded clayey sands and sandy clays are also present. Below the eolian sediments, clayey sands and sandy clays are thin and discontinuous. Individual stratigraphic units trend from southeast to northwest. Figure A-2 is a cross-section drawn perpendicular to this trend and indicates the approximate width of individual low permeability beds.

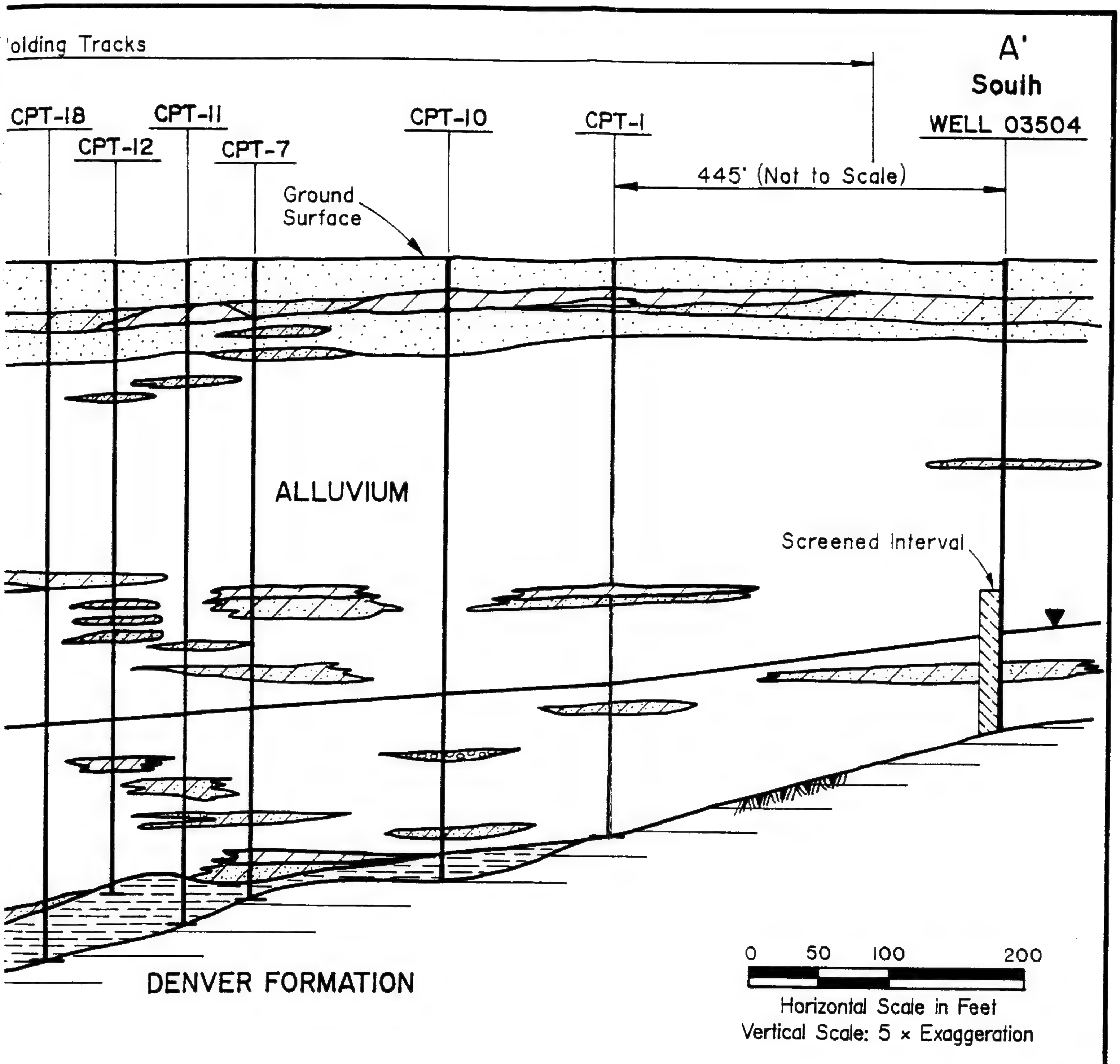
The alluvium is underlain by the northwest-sloping erosional surface of the Denver Formation (Figure A-3). The Denver Formation lithology varies between light green to brown claystone and green to black shale.

2.2 SITE HYDROLOGY

The water table beneath the railyard occurs in the alluvium and is from 55 to 75 feet below the ground surface (Figure A-4). As illustrated in Figure A-5, the water table slopes to the northwest and the primary components of flow are north and



A
North
Holding Tracks
CPT-14
CPT-4
CPT-3
CPT-6
CPT-13
(Projected)
CPT-18
400' (Not to Scale)
Surface
Hot Spot
Elevation (FT.) Mean Sea Level
5200
5180
5160
5140
5120
Bedrock Surface
Projected From
Well 03502,
200 Ft. Southwest
LEGEND
Clay
Claystone
Shale
Clayey Sand
Silty Sand -
Low Density
CPT-14



Gravel

Well Graded Sand with Occasional Gravel

CPT-14 Cone Penetration Test Hole

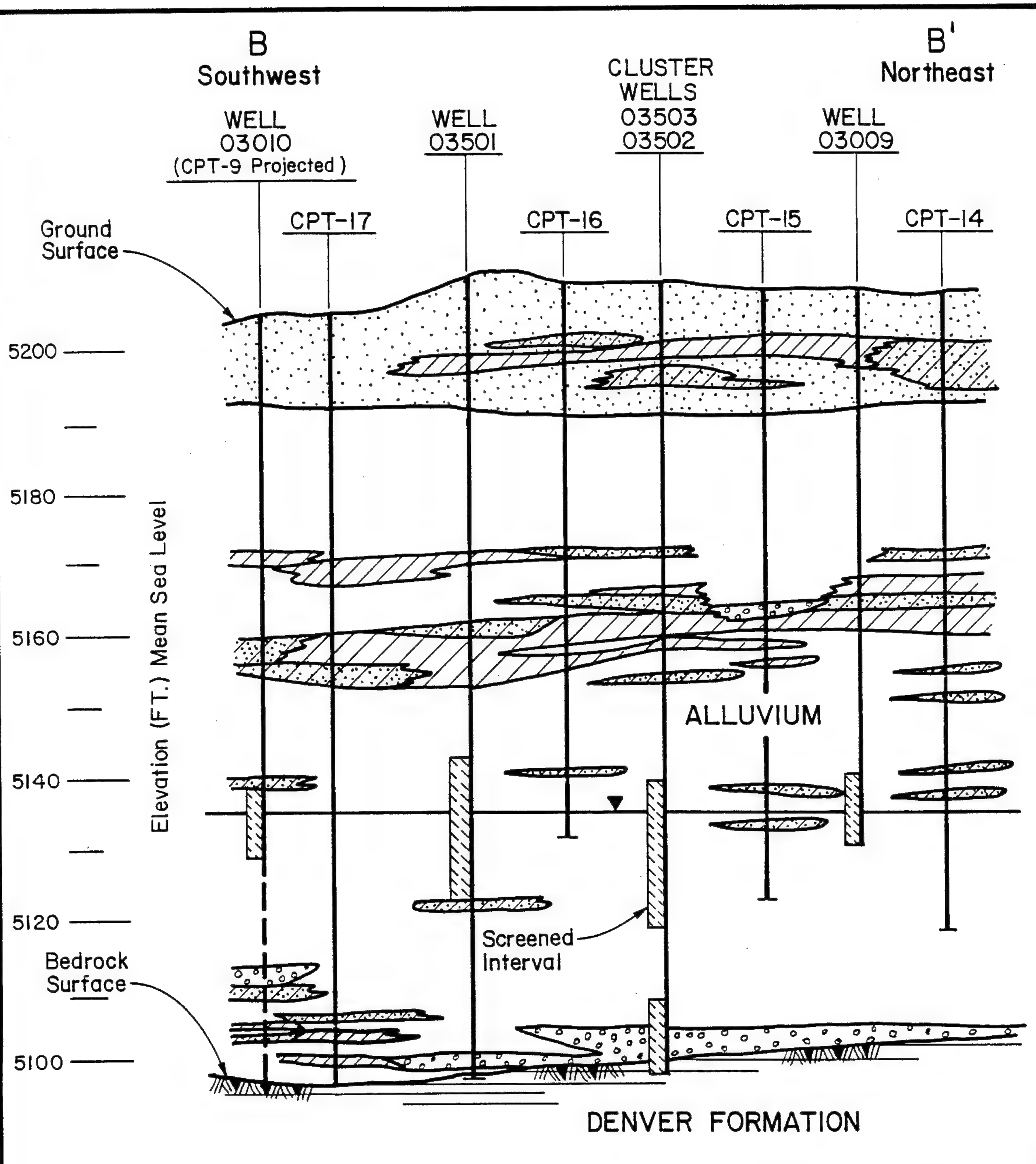
Water Level: July 1989

Figure: A-1

Hydrogeologic Cross Section A-A'

Prepared by : MK-Environmental Services

Date : Aug. 14, 1989



LEGEND

- Clay
- Shale
- Clayey Sand
- Well Graded Sand
- Gravel
- Silty Sand
- CPT-17 Cone Penetration Test Hole
- Water Level: July, 1989

0 50 100 200

Horizontal Scale in Feet

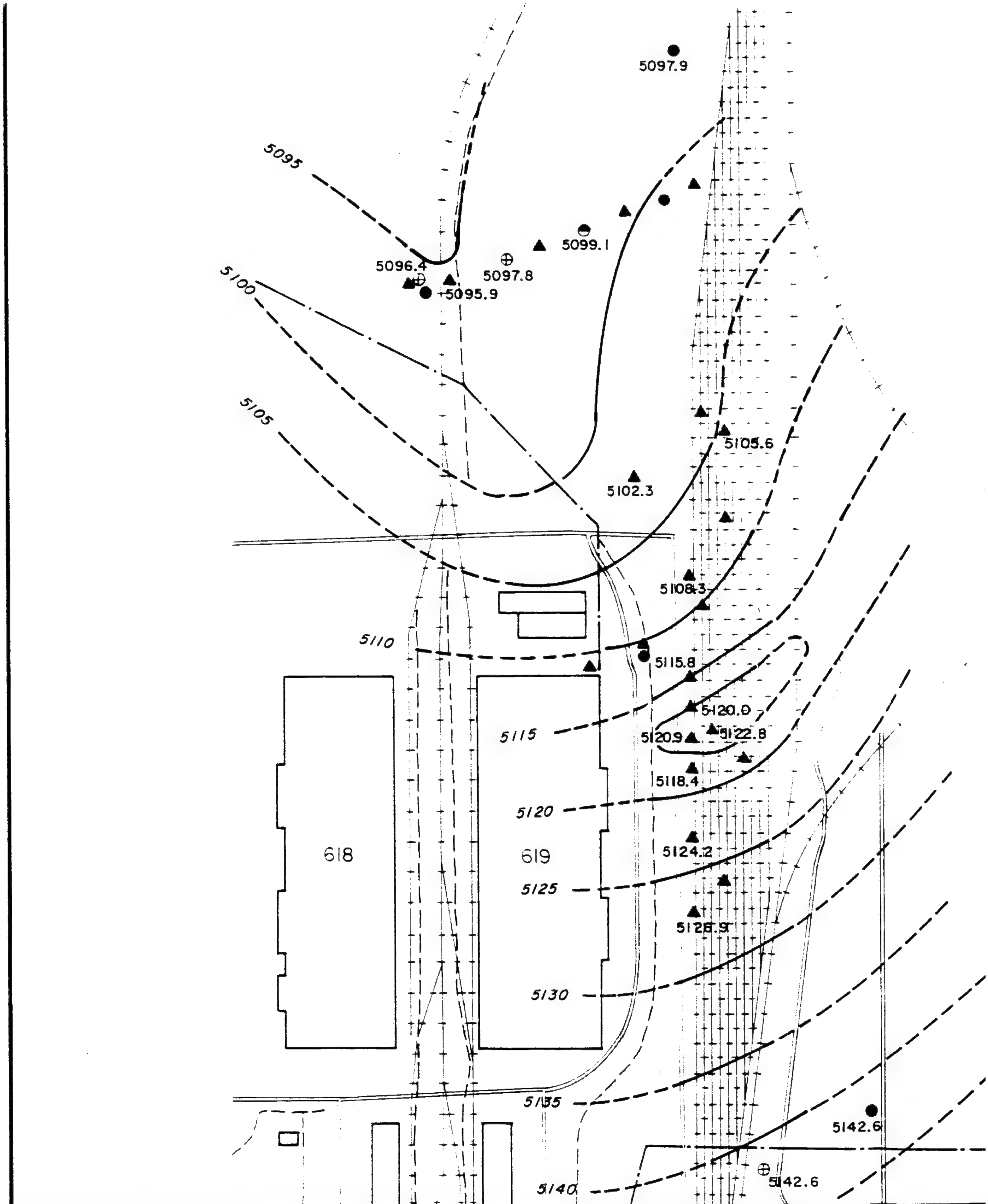
Vertical Scale: 5x Exaggeration

Figure: A-2

Hydrogeologic Cross Section B-B'

Prepared by:
MK-Environmental Services

Date: Aug. 14, 1989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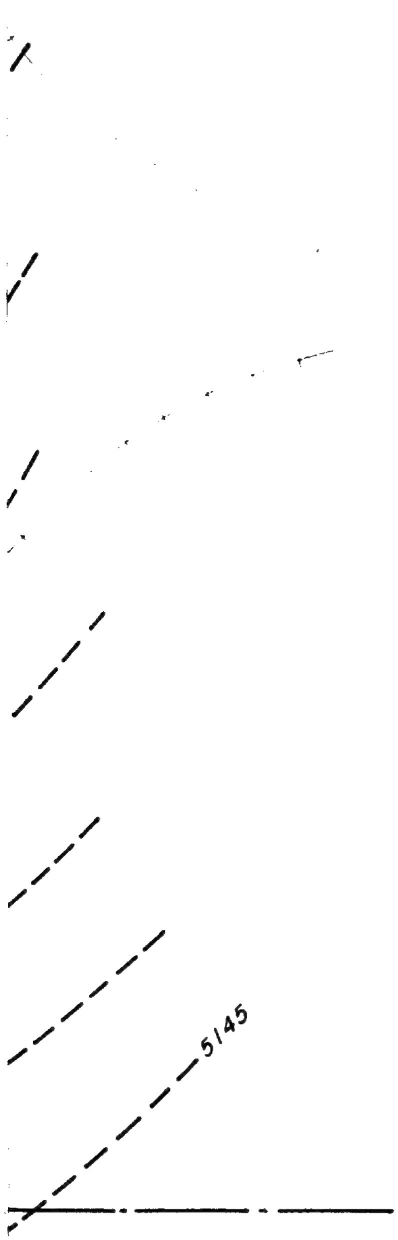


Legend

619 Building

Road

Railroad

Sanitary Sewer

Drainage

Previously Existing Alluvial Monitoring Well

Newly Installed Alluvial Monitoring Well

Newly Installed Alluvial Cluster Well

Cone Penetrometer Test Boring

5097.9 Elevation of the Top of Denver Formation in Feet Above Mean Sea Level.

5100 Contour Showing Elevation of Top of Denver Formation in Feet Above Mean Sea Level; Dashed Where Inferred.

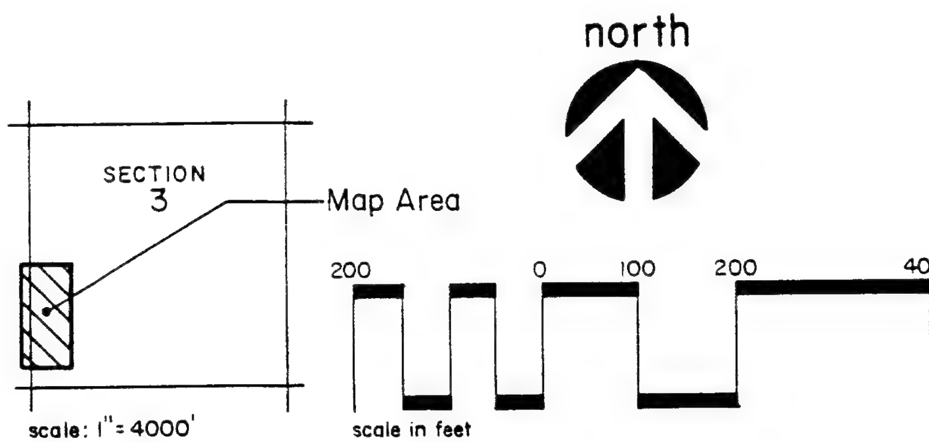
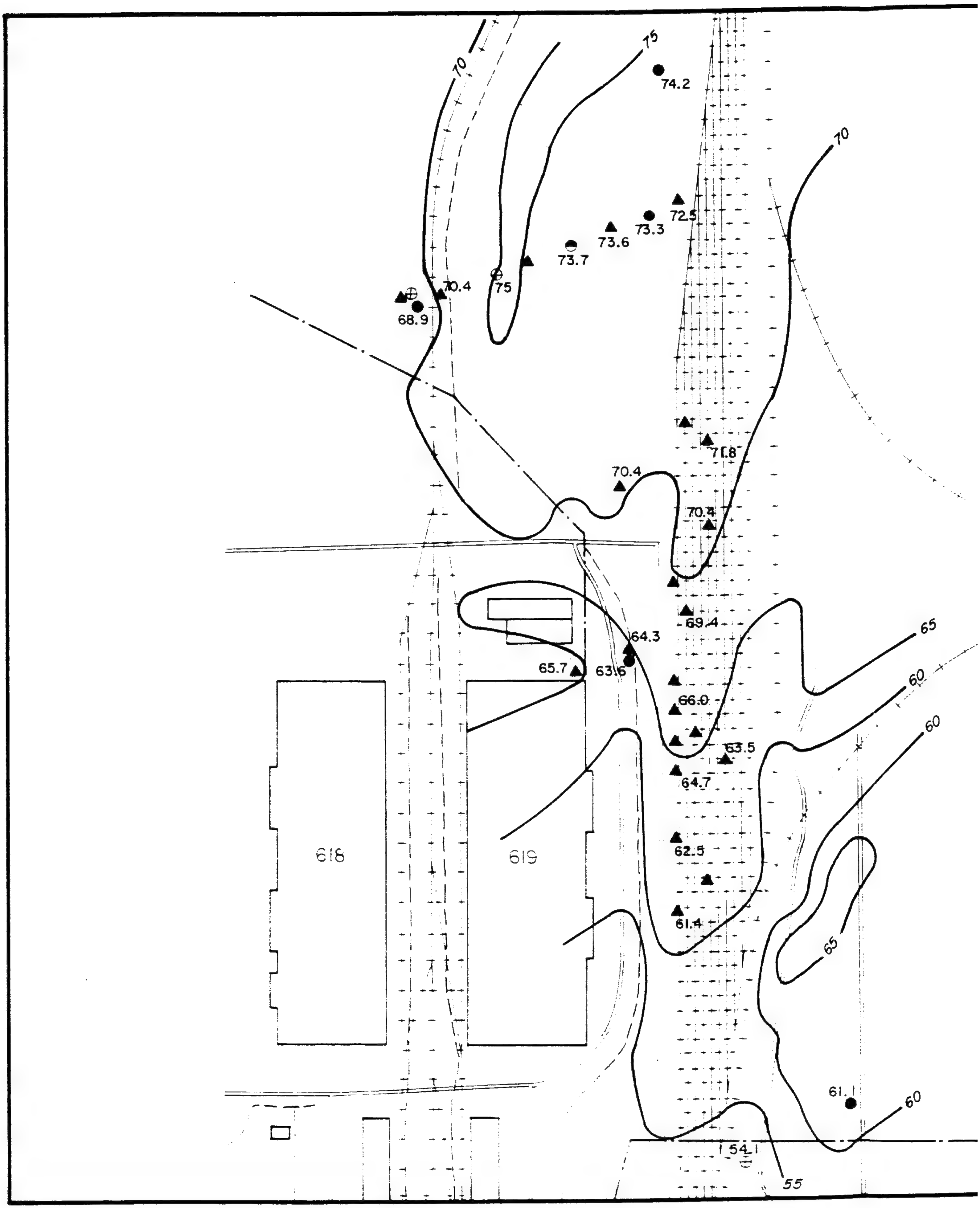


Figure: A-3

Bedrock Surface Elevation

Prepared by:

MK-ENVIRONMENTAL SERVICES
A DIVISION OF MK-FERGUSON



70
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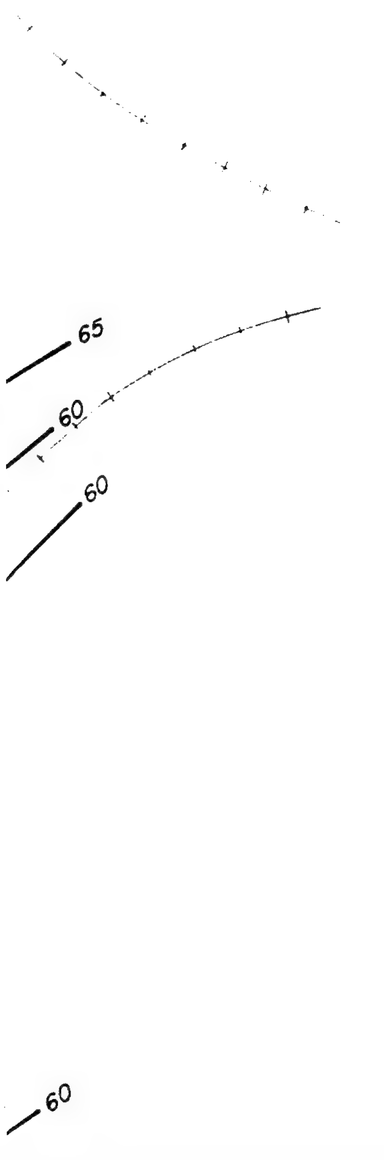


Legend

619 Building

Road

Railroad

Sanitary Sewer

Drainage

Previously Existing Alluvial Monitoring Well

Newly Installed Alluvial Monitoring Well

Newly Installed Alluvial Cluster Well

Cone Penetrometer Test Boring

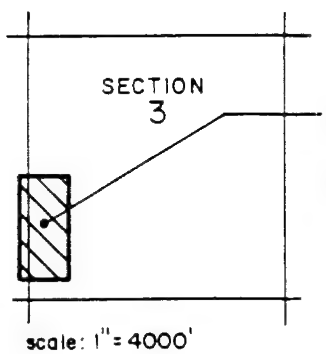
73.3 Thickness of the Vadose Zone in feet

60 Isopach Showing Thickness of Vadose Zone in Feet

NOTE:

Detail was obtained by using the Water Table Map and Surface Topographpy from Aerial Photography Dated 11-13-88

north



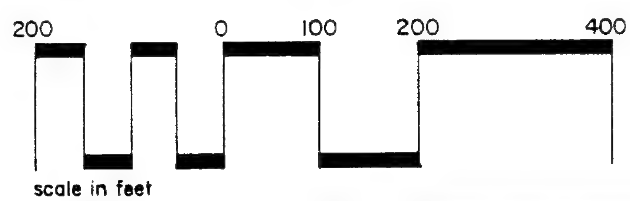
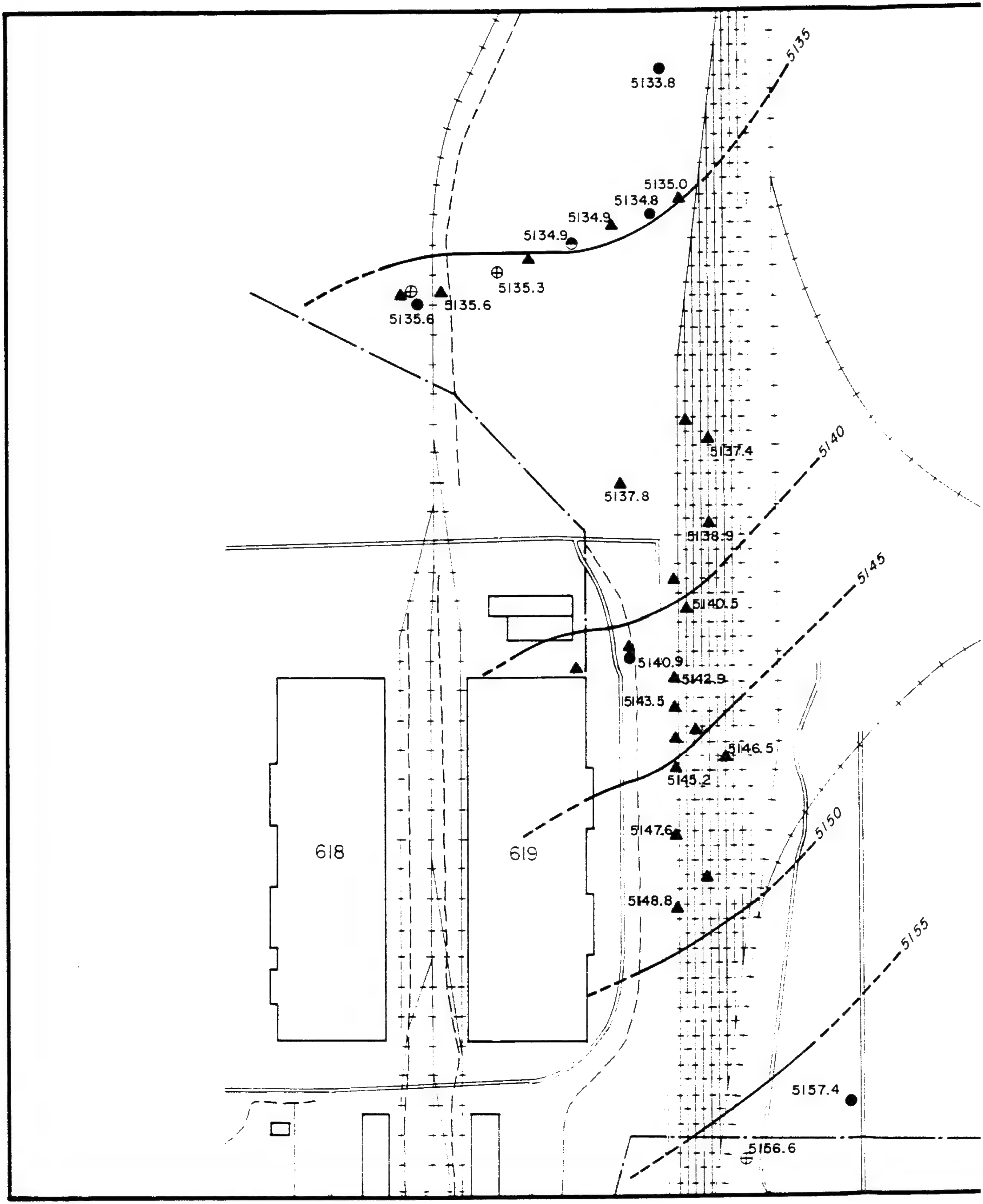


Figure: A-4

Thickness of the Vadose Zone
July 1989

Prepared by:

MK–ENVIRONMENTAL SERVICES
A DIVISION OF MK-FERGUSON



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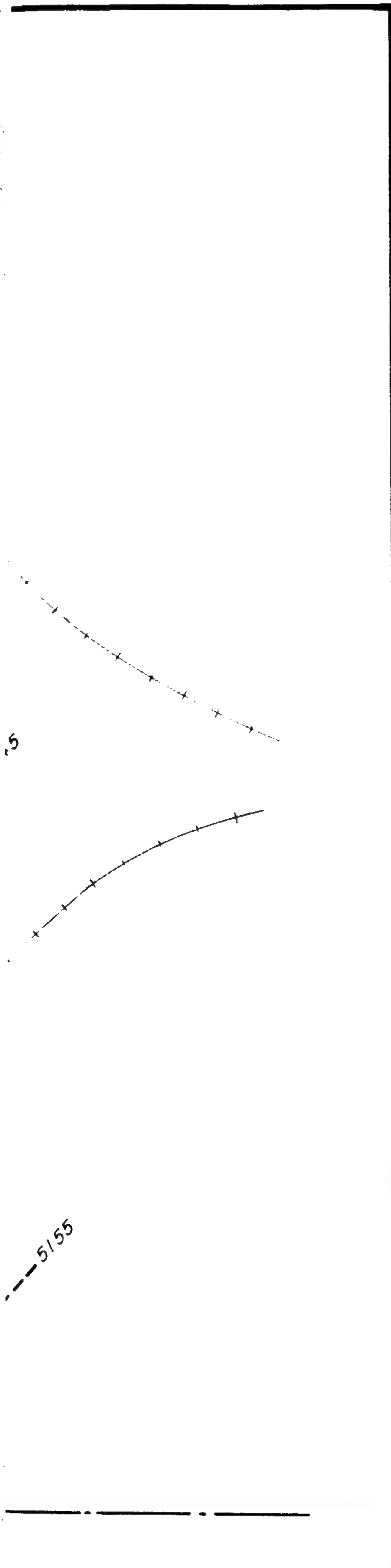


Legend

619 Building

Road

Railroad

Sanitary Sewer

Drainage

Previously Existing Alluvial Monitoring Well

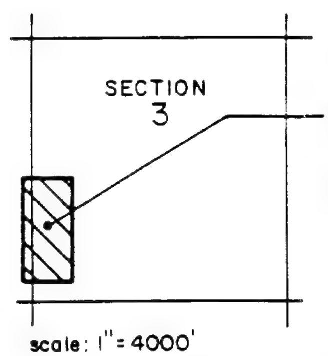
Newly Installed Alluvial Monitoring Well

Newly Installed Alluvial Cluster Well

Cone Penetrometer Test Boring

5133.8 Elevation of Water Level in Feet Above Mean Sea Level.

5140 Contour Showing Water Level Surface Elevation in Feet Above Mean Sea Level; Dashed Where Inferred.



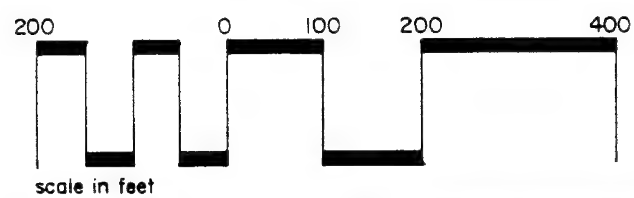


Figure: A-5

Contour Map of the Water Table
July 1989

Prepared by:

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A DIVISION OF MK-FERGUSON

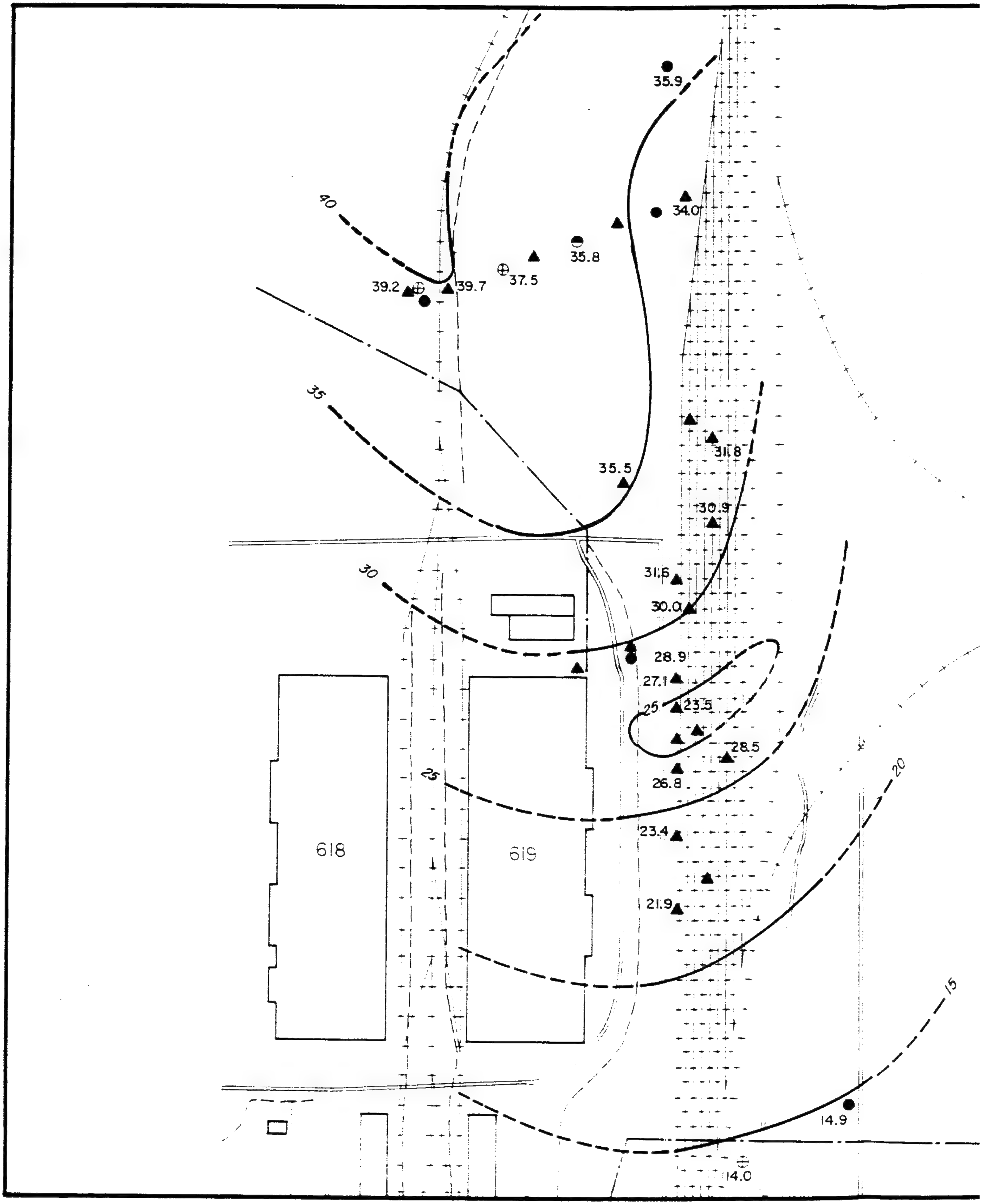
northwest. Lateral hydraulic gradient ranges from 0.006 to 0.02 ft/ft in the railyard area. The thickness of saturated alluvium varies from 15 feet in the south to 40 feet in the north (Figure A-6).

Water level elevation data collected since 1981 for Wells 03008, 03009, 03010, and 03523 indicate that seasonal variation is minor. During 1982 and 1983, water levels were approximately 2 feet lower than those at present. Since 1984, water levels have remained relatively stable.

Hydraulic conductivity was measured by one field aquifer test and two laboratory tests. The aquifer test was performed in downgradient Well 03505 and resulted in an estimated alluvial conductivity of 1.3×10^{-3} ft/s (4.0×10^{-2} cm/s). Laboratory hydraulic conductivity tests were conducted on two saturated sediment samples collected from Shell boring RCY2BR, located near Well 03523 and CPT-2. Conductivities of 5.9×10^{-4} ft/s (1.8×10^{-2} cm/s) and 7.0×10^{-4} ft/s (2.1×10^{-2} cm/s) were measured.

The discrepancy between the field and laboratory tests may result either from real differences in permeability (i.e., the aquifer is more gravelly at Well 03505 than Well 03523) or from differences in the thickness of saturated material tested (i.e., laboratory testing of a sample measures the conductivity of a small interval, whereas the aquifer test measures conductivity over the entire 40 feet of saturated material).

Recharge occurs to the alluvial aquifer through infiltration and percolation of precipitation. In the railyard area, recharge may be enhanced by ponding in the cobble ballast underlying the tracks. Enhanced recharge is indicated by saturated surface conditions, which were commonly observed beneath the railroad track ballast during the winter and summer of 1989. Pore pressure data from cone penetration testing also indicated high moisture content in the vadose zone beneath the ballast.



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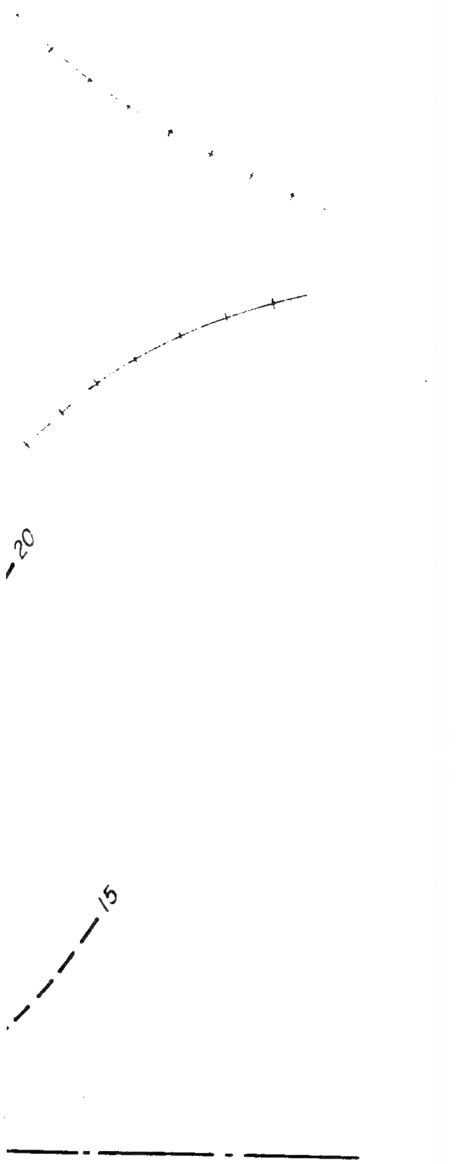
619



Legend

619 Building

Road

Railroad

Sanitary Sewer

Drainage

Previously Existing Alluvial Monitoring Well

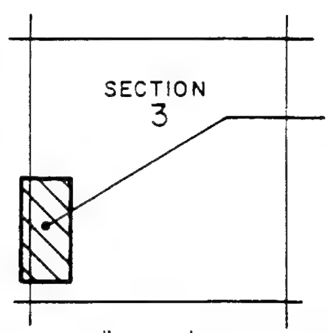
Newly Installed Alluvial Monitoring Well

Newly Installed Alluvial Cluster Well

Cone Penetrometer Test Boring

35.9 Thickness of Saturated Alluvium in Feet

35 Isopach Showing Thickness of Saturated Alluvium in Feet; Dashed Where Inferred.



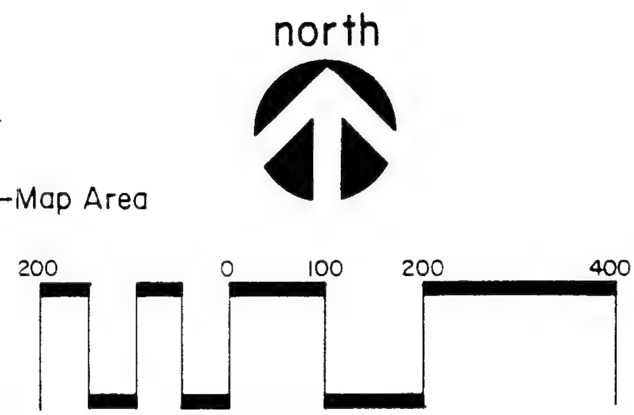


Figure: A-6

Thickness of Saturated Alluvium July 1989

Prepared by:

MK-ENVIRONMENTAL SERVICES
A DIVISION OF MK-FERGUSON

2.3 GROUNDWATER QUALITY

The results of groundwater analyses are summarized in Tables A-3 and A-4, and tabulated in Appendices D and E. The April 1989 configuration of the DBCP plume from the railyard to the Irondale Boundary System is shown in Figure A-7 and the distribution of DBCP in the railyard is illustrated in Text Figure 7.

In the railyard, DBCP concentrations in groundwater range from less than 0.01 to 9 ug/l for the CPT samples and from less than 0.13 to 12.1 ug/l for well samples. Concentrations of less than 1 ug/l were detected in CPTs located in the tracks, while concentrations greater than 1 ug/l were detected in the interior of the plume and upgradient of Well 03523.

In the railyard, the plume is approximately 500 feet wide (Text Figure 7). The western and eastern limits are well defined, while the upgradient limit is defined at only a few locations.

The vertical distribution of DBCP is shown on two cross-sections (Figures A-8 and A-9). Figure A-8 is oriented at an angle oblique to the plume, while Figure A-9 is perpendicular to the plume. Figure A-8 illustrates the high concentrations detected in CPT-12, upgradient from Well 03523. Concentrations of DBCP in CPT-12 decrease with depth but extend to the alluvial-Denver Formation contact. To the north of CPT-12, concentrations of DBCP decrease to below detection limit above the alluvial-Denver Formation contact.

Figure A-10 provides a comparison between annual precipitation at Stapleton International Airport and water level and water quality data for Well 03523 from 1981 through 1989. Above-average precipitation in 1983 through 1985 resulted in higher water levels in Well 03523. The concentration of DBCP decreased to a low in early 1983, and then sharply increased in

TABLE A-3 SUMMARY OF GROUNDWATER ANALYTICAL RESULTS FOR MONITORING WELLS

Well	Sample Date	Quality Control Samples	DBCP Concentration (ug/l)
03001	4/12/89	--	<0.13
03009 (Shell)	4/13/89	--	0.90
	7/89	--	0.96*
03010	4/12/89	--	<0.13
03501	4/12/89	--	6.0
03502	4/12/89	--	<0.13
03503	4/12/89	--	5.8
	4/12/89	D	10
	4/12/89	R	<0.13
03504	4/12/89	--	<0.13
03523 (Shell)	4/13/89	--	23
	4/13/89	R	<0.13
	7/89	--	12.1*

Explanation

*Preliminary Data

Quality Control Sample Types:
D = Duplicate
R = Rinse Blank

Samples Analyzed by Method Q8 (EPA Method 504)

TABLE A-4 SUMMARY OF ANALYTICAL RESULTS FOR CONE PENETROMETER SAMPLING

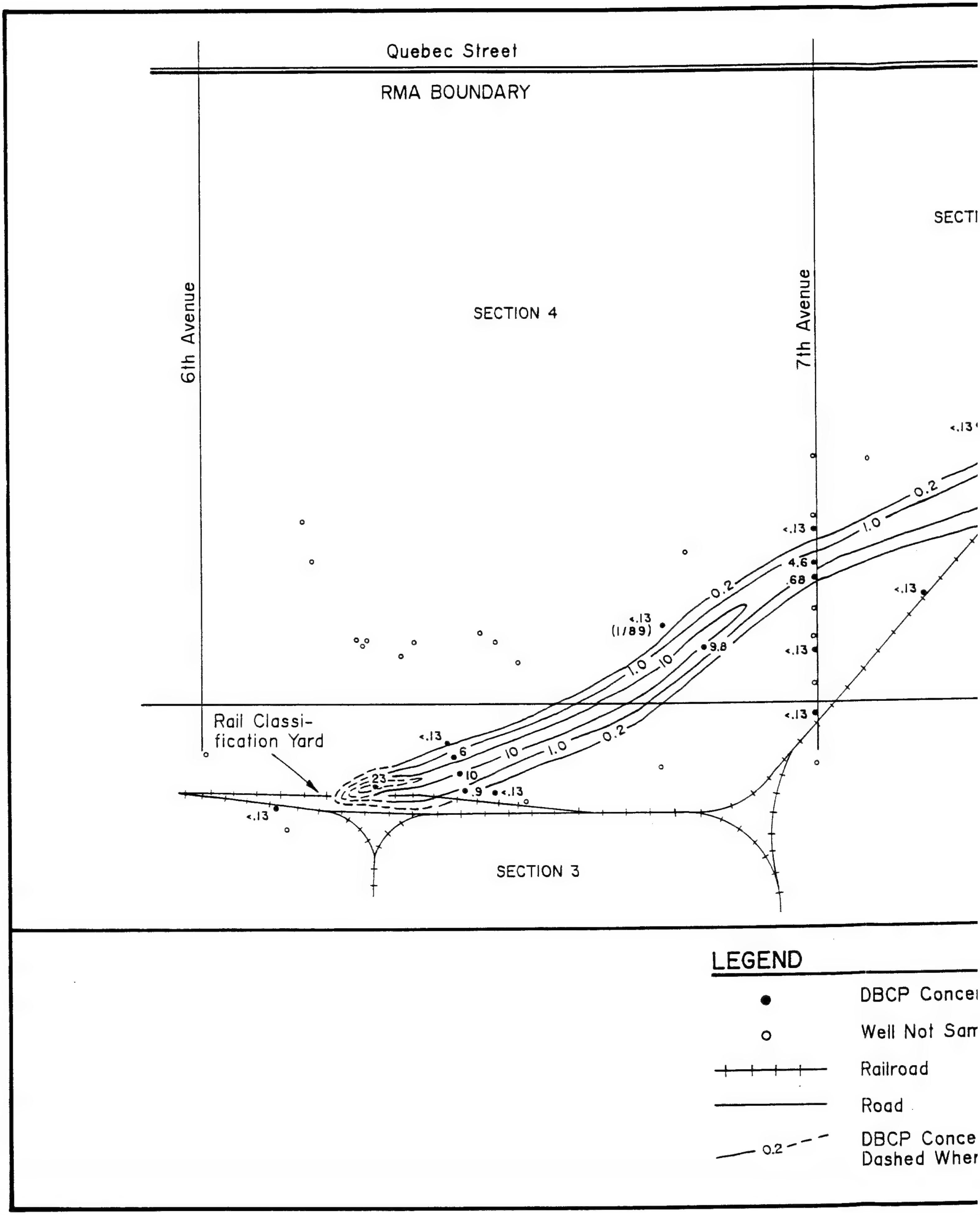
Location	Sample ID	Sample Date	Sample Depth (ft)	DBCP Concentration (ug/l)
CPT-1	CPT-1-W-21.4 F	7/5/89	70.2	<0.01
	CPT-1-W-21.4 B	7/5/89	70.2	<0.01
CPT-2	CPT-2-W-19.95 A	7/3/89	65.5	0.4
	CPT-2-W-19.95 B	7/3/89	65.5	3
	CPT-2-W-19.95 C	7/3/89	65.5	<0.01
	CPT-2-W-24.2 B	7/3/89	79.4	5
	CPT-2-W-24.2 D	7/3/89	79.4	6
CPT-3	CPT-3-W-24.3 B	7/6/89	79.7	0.1
	CPT-3-W-24.3 F	7/6/89	79.7	0.1
CPT-4	CPT-4-W-25.0 B	7/7/89	82.0	<0.01
	CPT-4-W-25.0 F	7/7/89	82.0	<0.01
CPT-6	CPT-6-W-23.7 B	7/6/89	77.8	0.03
	CPT-6-W-23.7 F	7/6/89	77.8	0.01
CPT-7	CPT-7-G-17.55	7/1/89	57.6	<0.0004
	CPT-7-W-20.35	7/1/89	66.8	0.2
	CPT-7-W-24.0	7/1/89	78.7	0.2
	CPT-7-W-25.8	7/1/89	84.6	0.07
CPT-8	CPT-8-W-20.4	7/2/89	66.9	<0.01
CPT-10	CPT-10-G-19.0	7/4/89	62.3	0.0009
	CPT-10-W-19.6 B	7/4/89	64.3	0.4
	CPT-10-W-21.8 B	7/4/89	71.5	0.3
	CPT-10-W-23.8 B	7/4/89	78.1	0.09
	CPT-10-W-26.0 A	7/4/89	85.3	<0.1
CPT-11	CPT-11-W-20.5 B	7/19/89	67.3	0.004
	CPT-11-W-26.0 B	7/19/89	85.3	0.01
CPT-12	CPT-12-W-20.6 B	7/20/89	67.5	9
	CPT-12-W-26.0 B	7/20/89	86.9	3
CPT-13	CPT-13-W-22.5 B	7/21/89	73.8	0.7
	CPT-13-W-27.8 B	7/21/89	91.2	0.3
CPT-14	CPT-14-W-23.0 B	7/22/89	75.3	0.04
	CPT-14-W-25.2 B	7/22/89	82.6	0.03
CPT-15	CPT-15-W-23.8 B	7/26/89	78.2	6
	CPT-15-W-23.8 F	7/26/89	78.2	2
CPT-16	CPT-16-W-23.9 B	7/25/89	78.3	4
	CPT-16-W-23.9 F	7/25/89	78.3	2

Location	Sample ID	Sample Date	Sample Depth (ft)	DBCP Concentration (ug/l)
CPT-17	CPT-17-W-23.1 B	7/25/89	75.7	0.1
	CPT-17-W-23.1 F	7/25/89	75.7	0.08
	CPT-17-W-28.1 B	7/25/89	92.3	0.007
	CPT-17-W-28.1 F	7/25/89	92.3	0.01
CPT-18	CPT-18-W-21.0 B	7/26/89	68.7	0.04
	CPT-18-W-26.0 B	7/26/89	85.4	0.03
CPT-19	CPT-19-W-21.1 B	7/27/89	69.2	0.07
	CPT-19-W-23.7 B	7/27/89	77.8	0.02
CPT-20	CPT-20-W-21.1 B	7/28/89	69.2	0.007
	CPT-20-W-23.0 B	7/28/89	75.4	0.5
C-3	C3-W-24.8 B	7/7/89	81.4	<0.01
	C3-W-24.8 F	7/7/89	81.4	<0.01
C-4	C4-W-23.3 B	7/7/89	73.1	<0.01
	C4-W-23.3 F	7/7/89	73.4	<0.01
Well 03523	03523 A	7/3/89	72	3
	03523 B	7/3/89	72	1
	03523 D	7/3/89	72	4
	03523 E1	7/3/89	72	5
	03523 E2	7/3/89	72	6

Note: Groundwater Samples Analyzed by EPA Method 504.

Explanation

A = Single Volume Sample (<40 ml)
B = 40 ml Sample
C = Rinse Blank
D = Headspace Analysis
E = Well Bailer Sample
F = Filtered Sample
G = Soil Gas Sample
W = Groundwater Sample



Quebec Street
RMA BOUNDARY
6th Avenue
7th Avenue
SECTION 4
SECTI
SECTION 3
Rail Classi-
fication Yard
0.2
1.0
10
<.13
(1/89)
9.8
4.6
.68
23
6
9
LEGEND
DBCP Conce
Well Not Sam
Railroad
Road
DBCP Conce
Dashed Wher

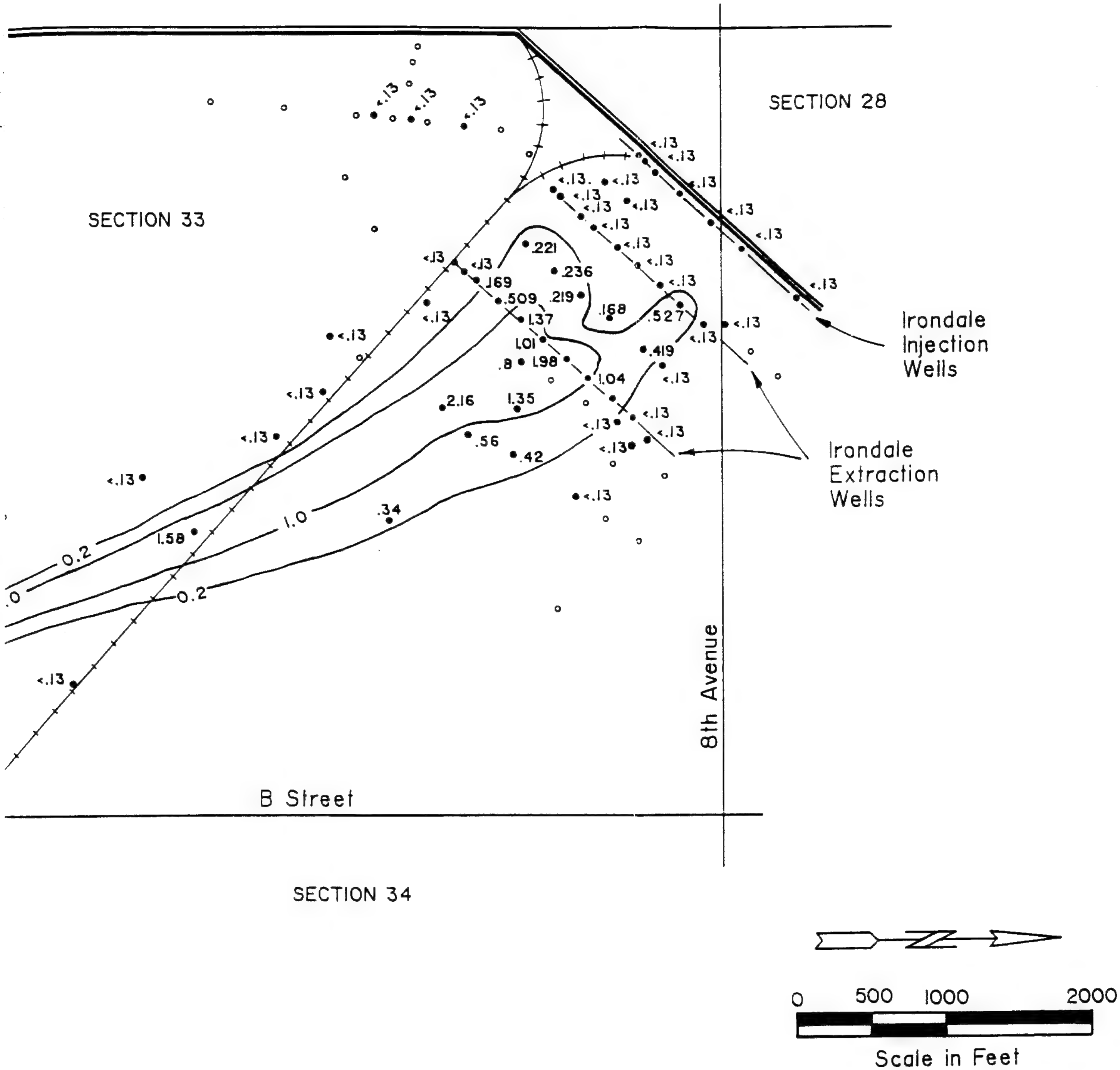


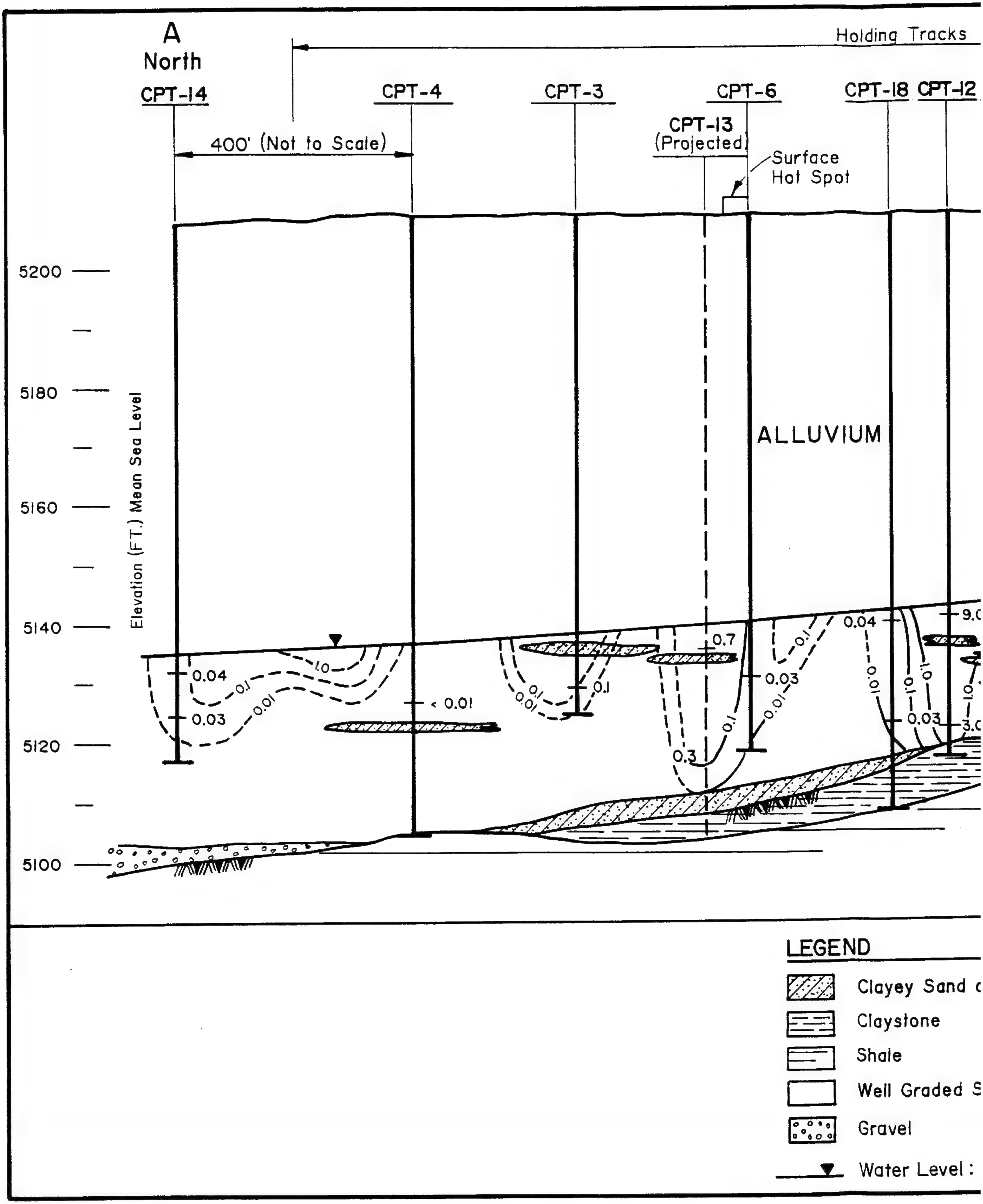
Figure: A-7

BCP Concentration in µg/L
/ell Not Sampled
ailroad
oad
BCP Concentration Contour,
ashed Where Inferred

DBCP Plume in the Alluvial Aquifer, April 1989

Prepared by : MK-Environmental Services

Date : Aug. 14, 1989



A
North
Holding Tracks
CPT-14
CPT-4
CPT-3
CPT-6
CPT-18
CPT-12
CPT-13
(Projected)
400' (Not to Scale)
Surface
Hot Spot
ALLUVIUM
5200
5180
5160
5140
5120
5100
Elevation (FT.) Mean Sea Level
0.04
0.03
0.1
0.01
1.0
< 0.01
0.1
0.01
0.1
0.7
0.03
0.01
0.1
0.3
0.04
0.03
LEGEND
Clayey Sand
Claystone
Shale
Well Graded
Gravel
Water Level :

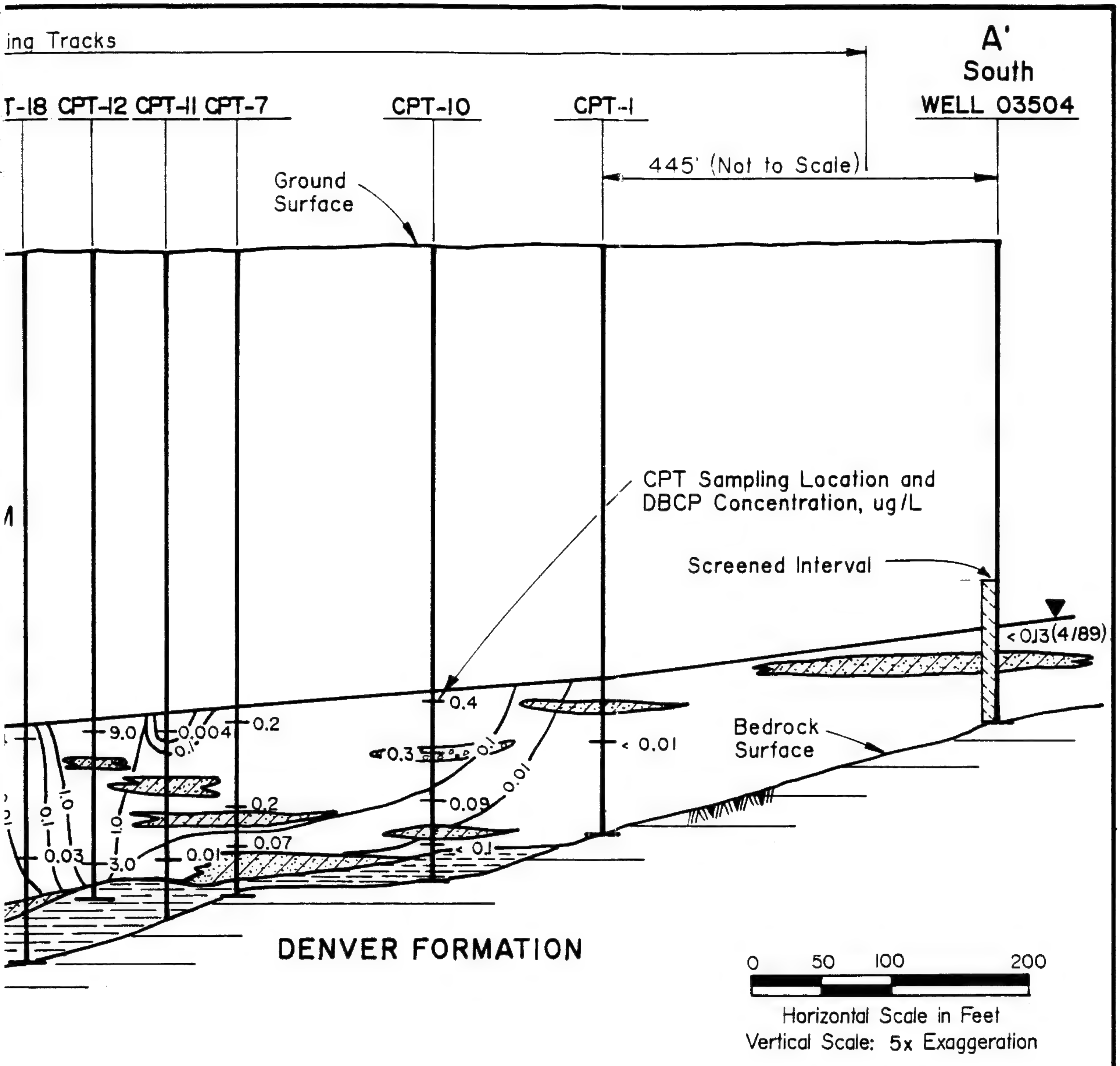


Figure: A-8

ayey Sand and Clay

aystone

ale

ell Graded Sand and Gravel

avel

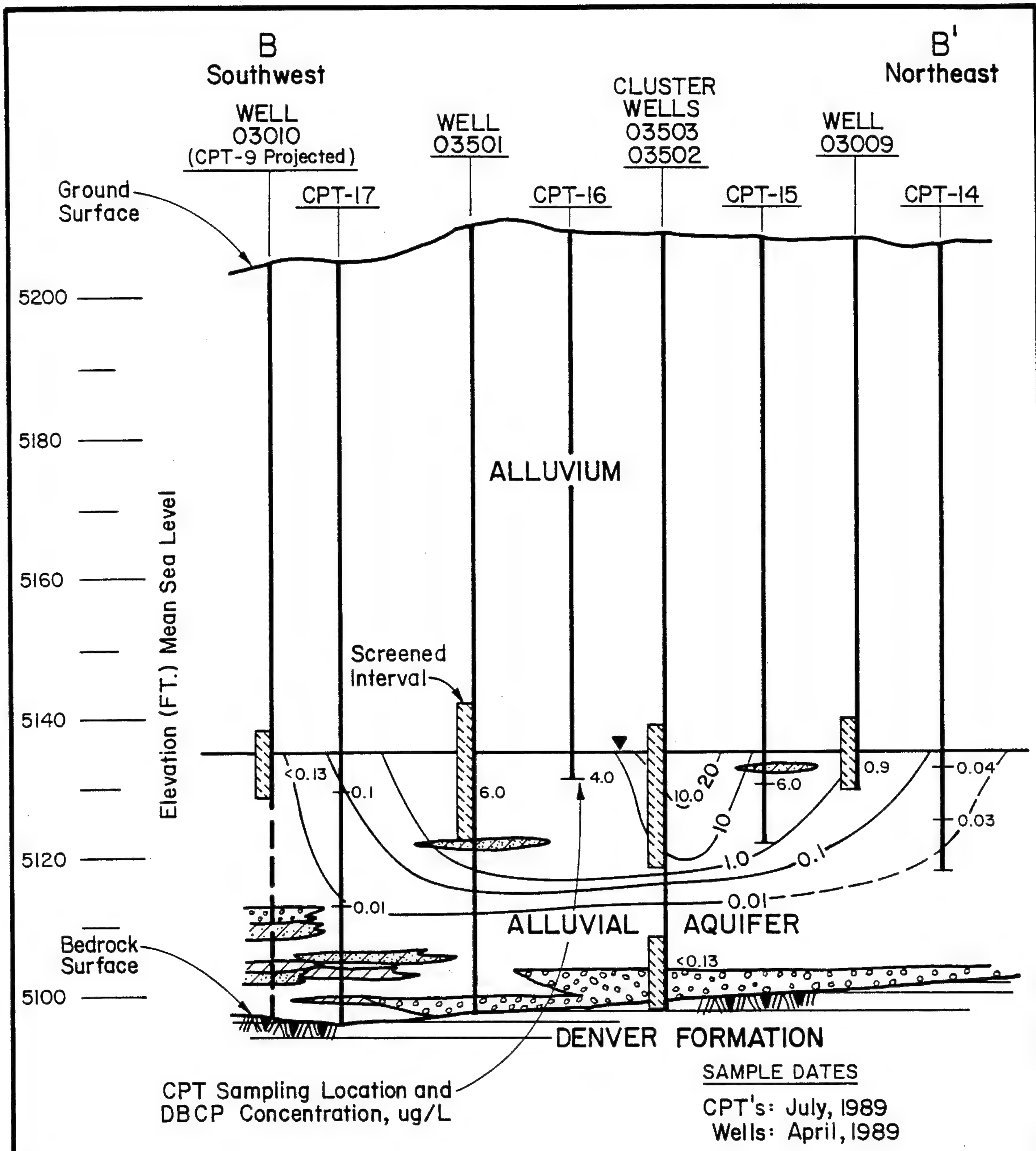
ater Level : July, 1989

Water Quality

Cross Section A-A'

Prepared by : **MK-Environmental Services**

Date : Aug. 14, 1989



LEGEND

- Clay
- Shale
- Clayey Sand
- Well Graded Sand
- Gravel

CPT-17 Cone Penetration Test Hole

Water Level : July, 1989

0 50 100 200

Horizontal Scale in Feet

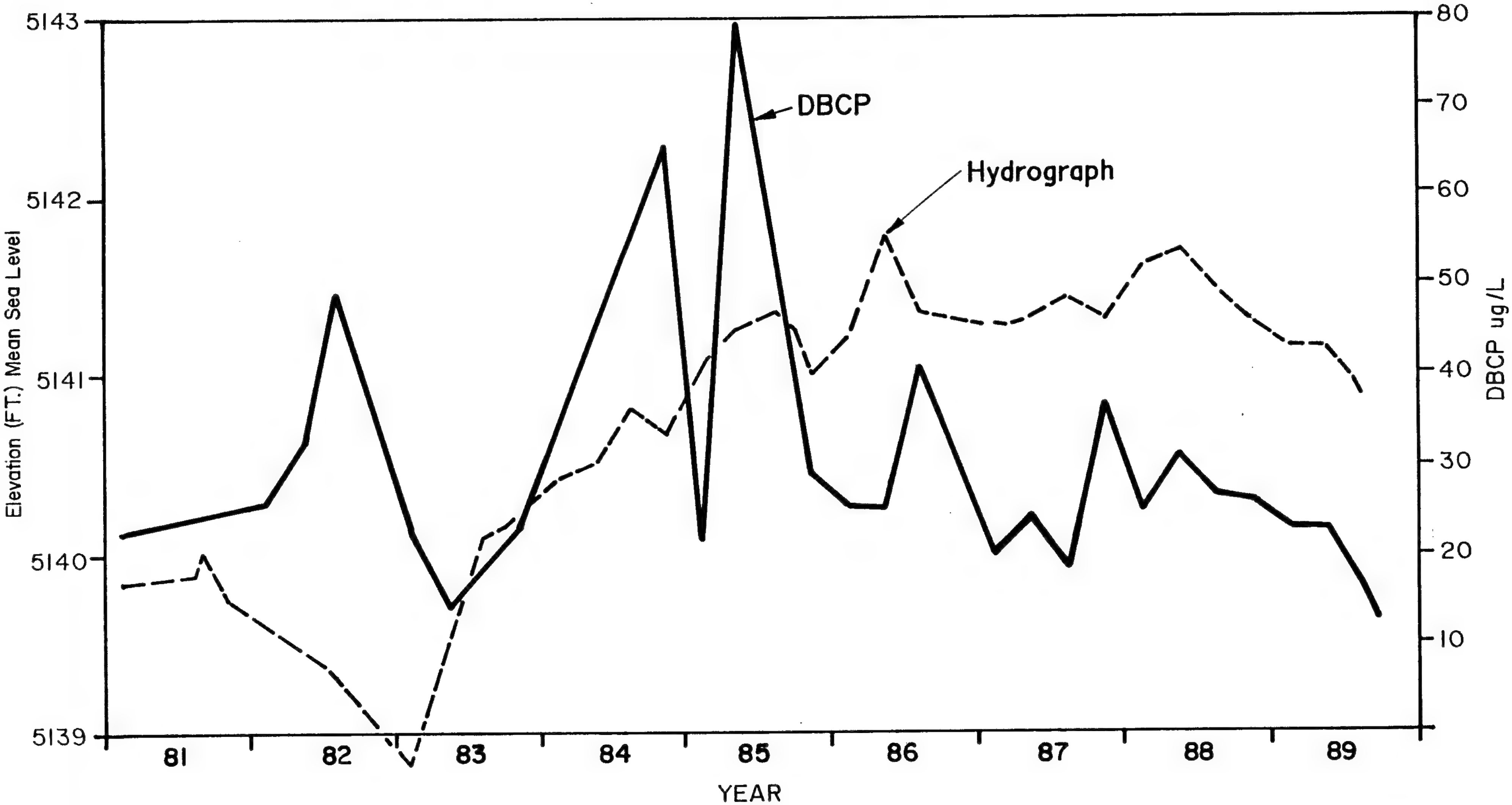
Vertical Scale: 5 x Exaggeration

Figure: A-9

Water Quality Cross Section B-B'

Prepared by:
MK-Environmental Services

Date: Aug. 14, 1989



12.59	14.45	20.19	16.49	16.31	12.09	20.03	14.96	9.23 (to 7/1/89)
Annual Precipitation (inches) at Stapleton International Airport								

Figure: A-10

Well 03523

Hydrograph and Water Quality

Prepared by : MK-Environmental Services

Date : Aug. 14, 1989

1984 and again in 1985 as additional DBCP was either leached from the vadose zone by additional recharge or diluted by rising water levels. Since 1985, both water levels and concentrations have been generally stable, although both have consistently decreased through 1989.

2.3.1 Results of USATHAMA Analytical and QA/QC Data

Analyses of samples from the six wells used in the present investigation and two QC samples were validated by USATHAMA. The Certified Reporting Limit for DBCP for the analytical method used is 0.13 ug/l. Field QC sample analyses are included in Appendix D. One rinse blank was collected after decontaminating sampling equipment used for Well 03503. No detectable concentration of DBCP was reported; therefore, decontamination procedures were adequate.

One duplicate sample was collected from Well 03503 and DBCP concentrations of 5.8 and 10 ug/l were detected in the sample and duplicate, respectively. The relative percent difference (rpd) is 53%, which is above a desirable range, but does not significantly alter the interpretation of the configuration of the plume. At these low concentrations, many variables in the well could cause the discrepancy.

2.3.2 Tracer Research Analytical Data QA/QC

The water quality data derived from onsite analyses of samples collected from the cone penetrometer survey are qualitative. With the standard sample analysis volume of 35 ml, detection limits were typically 0.01 ug/l.

In the first half of the cone penetrometer survey, three groundwater samples were duplicated and analyzed both by Tracer Research and a USATHAMA-certified laboratory (ESE). The results were as follows:

Sample Location	Depth ft	Tracer Research Sample ID	Tracer Research DBCP, ug/l	ESE Sample ID	ESE DBCP ug/l
CPT-2	79.4	CPT-2-W-24.2-B	5	CPT-2-A	5.32
CPT-10	78.1	CPT-10-W-23.8-B	0.09	CPT-10-A	0.165
03523	72	03523-B	1	03523-A	5.88

The relative percent differences range from 6 to 142 percent. Some of the variation may be explained by the fact that samples were not actual splits but collected consecutively. Additionally, Well 03523 was not purged prior to sampling, so variability in the well may have contributed to the variability in the analytical data.

After analysis of samples from CPT-1 through CPT-10, C-3, and C-4, a 1.0 ug/l standard of DBCP was prepared by RMAL for which Tracer reported a concentration of 0.4 ug/l. Evaluation of probable causes for the low recovery by Tracer indicated that the stock solution of DBCP, which was used to prepare calibration standards for the Tracer instruments, had been prepared improperly and had caused the low recovery. Although more accurate data are desirable, the analytical data derived from the onsite laboratory are believed to be adequate and were utilized for this initial investigation.

During a second phase of fieldwork (CPT-11 through CPT-20), a new stock solution was prepared by Tracer and another 1.0 ug/l standard was analyzed. A DBCP concentration of 0.99 ug/l was reported; thus, groundwater analyses of CPT-11 through CPT-20 are more accurate than the results for CPT-1 through CPT-10, C-3, and C-4.

A rinse blank was prepared after decontaminating the sample container used to collect CPT-2-W-19.95-B. The sample contained no detectable DBCP. A duplicate sample was bailed from Well 03523 and concentrations of 5 and 6 ug/l were reported.

Nine of the 20 CPT holes sampled had an unfiltered and filtered sample of groundwater collected. Of these nine, six samples contained detectable DBCP. Four of the six sample pairs had higher concentrations (by 1.25 to 3 times) in the unfiltered sample; however, one pair was the same, and in one pair, the filtered sample had a higher concentration than the unfiltered sample. Only the highest concentration samples were plotted and compared to the groundwater samples collected from wells and the standard CPT holes.

2.3.3 Conclusions - Groundwater Quality

Although the upgradient limit of the DBCP plume is not completely defined, it is probably within the holding track area. The highest concentrations in the plume originate upgradient from Well 03523 near CPT-12. Elsewhere, concentrations found in the holding tracks are relatively low (<1.0 ug/l).

The concentrations of DBCP in groundwater decrease with depth in the aquifer. This decrease in concentration indicates that the active sources are located either in the uppermost portion of the aquifer or in the vadose zone. A large mass of residual DBCP in the aquifer is unlikely since the solubility of DBCP is 1,200 mg/l and the highest concentration recently detected in the railyard is 12.1 ug/l (Well 03523).

The concentrations of DBCP in groundwater in the railyard source area have experienced an overall decline since 1985. The decrease in concentration may be due to depletion of the source or dilution from high water levels between 1985 to 1989.

2.4 SOIL GAS INVESTIGATION

The detection limits for DBCP using the Tracer Research onsite laboratory ranged from 0.00004 to 0.001 ug/l in soil gas and from 0.000005 to 0.009 ug/g in soil depending on the conditions

of the measurement (i.e., the sample size). The results from the Test Survey conducted in February 1989 and the expanded survey conducted in June 1989 are discussed below.

2.4.1 Test Survey

Text Figure 6 presents the results of the soil gas test survey which are also tabulated in Appendix F. A 20 by 30 foot spill was delineated centered on Track 2 with a maximum concentration of 2 ug/g. DBCP concentrations were highest in the upper 2 feet of soil and were detectable to a depth of at least 20 feet.

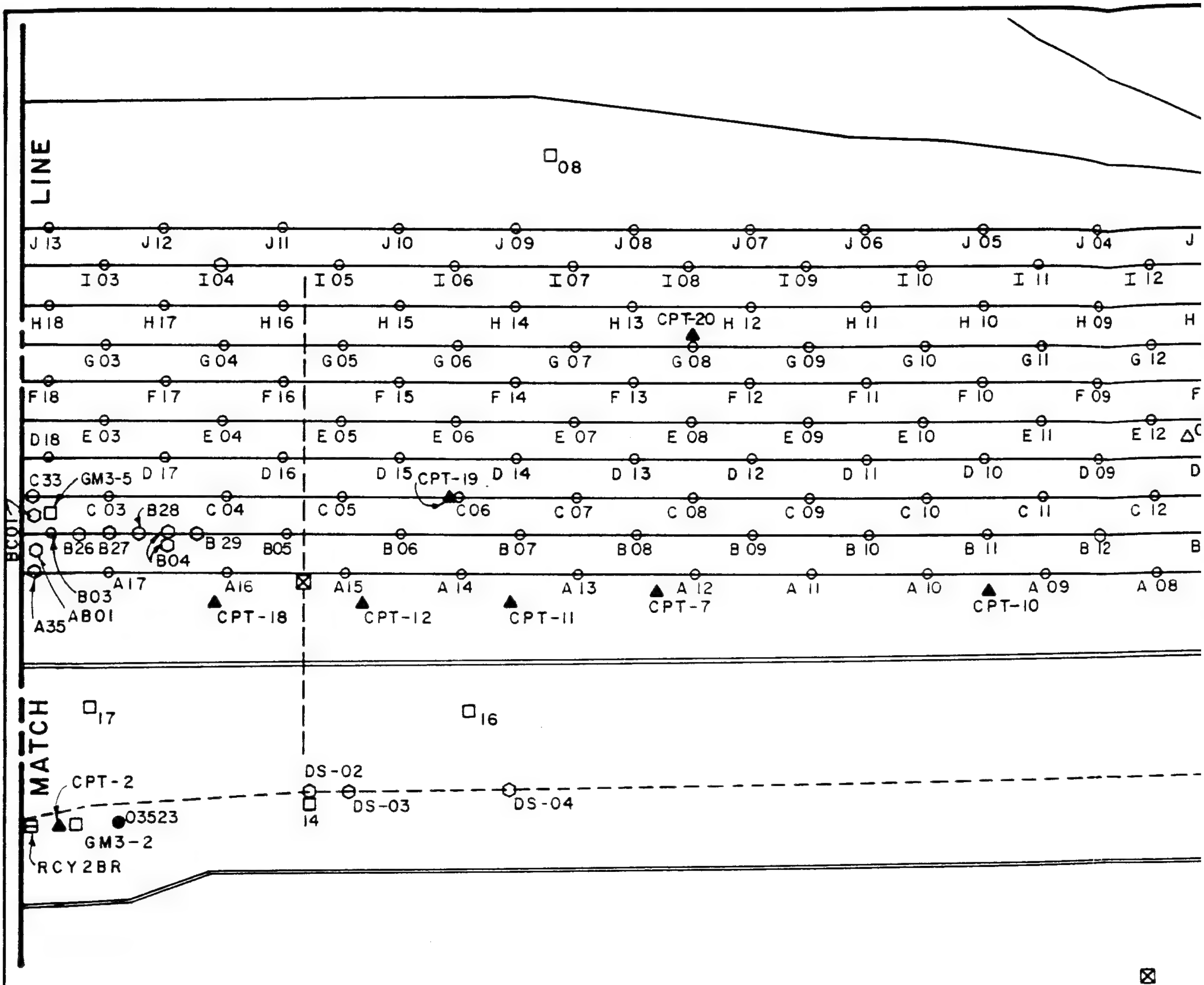
Concentrations ranged from 0.4 ug/g (400 ppb) near ground surface to 0.07 ug/g (70 ppb) twenty feet below ground surface. Increases in concentration occurred above lenses of clayey sand in the alluvium. These increases indicate that lenses of clayey sand and clay inhibit vertical migration of DBCP by adsorption or pooling of residual DBCP. The lenses may also provide lateral migration pathways for residual or vapor-phase DBCP.

2.4.2 Railyard Soil Gas Investigation

Figures A-11 and A-12 show the locations of previous soil sample data and the sampling locations for this investigation. The Army Petrex soil gas sampling locations are not shown.

Text Figures 4 and 5 illustrate the distribution of DBCP in the shallow soil and the analytical results are presented in Appendix G. The highest concentrations in soil or soil gas occurred in the Test Survey Site shown in Text Figures 5 and 6 and are discussed above.

The high density of detections near the Test Survey Site are probably due to spreading of the initial spill by surface flow of runoff to the south. DBCP concentrations in soil extraction samples near the Test Survey Site were low, with a maximum of 0.020 ug/g.



Legend

CPT-8

ROAD
RAILROAD TRACK
SURFACE DRAINAGE
TRACK DRAINAGE
CATCH BASIN

MONITORING WELLS

PREVIOUSLY EXISTING ALLUVIAL MONITORING WELL
NEWLY INSTALLED ALLUVIAL MONITORING WELL
NEWLY INSTALLED ALLUVIAL CLUSTER

CONE PENETRATION TEST BORINGS

LITHOLOGY PROFILE AND GROUNDWATER SAMPLING LOCATION.
GROUNDWATER SAMPLING LOCATION ONLY.

ARMY SOILS BORINGS

17 PHASE I & II
GM 3-4 GERAGHTY & MILLER

SHELL BORING

RCY2BR SATURATED SEDIMENT SAMPLE BORING

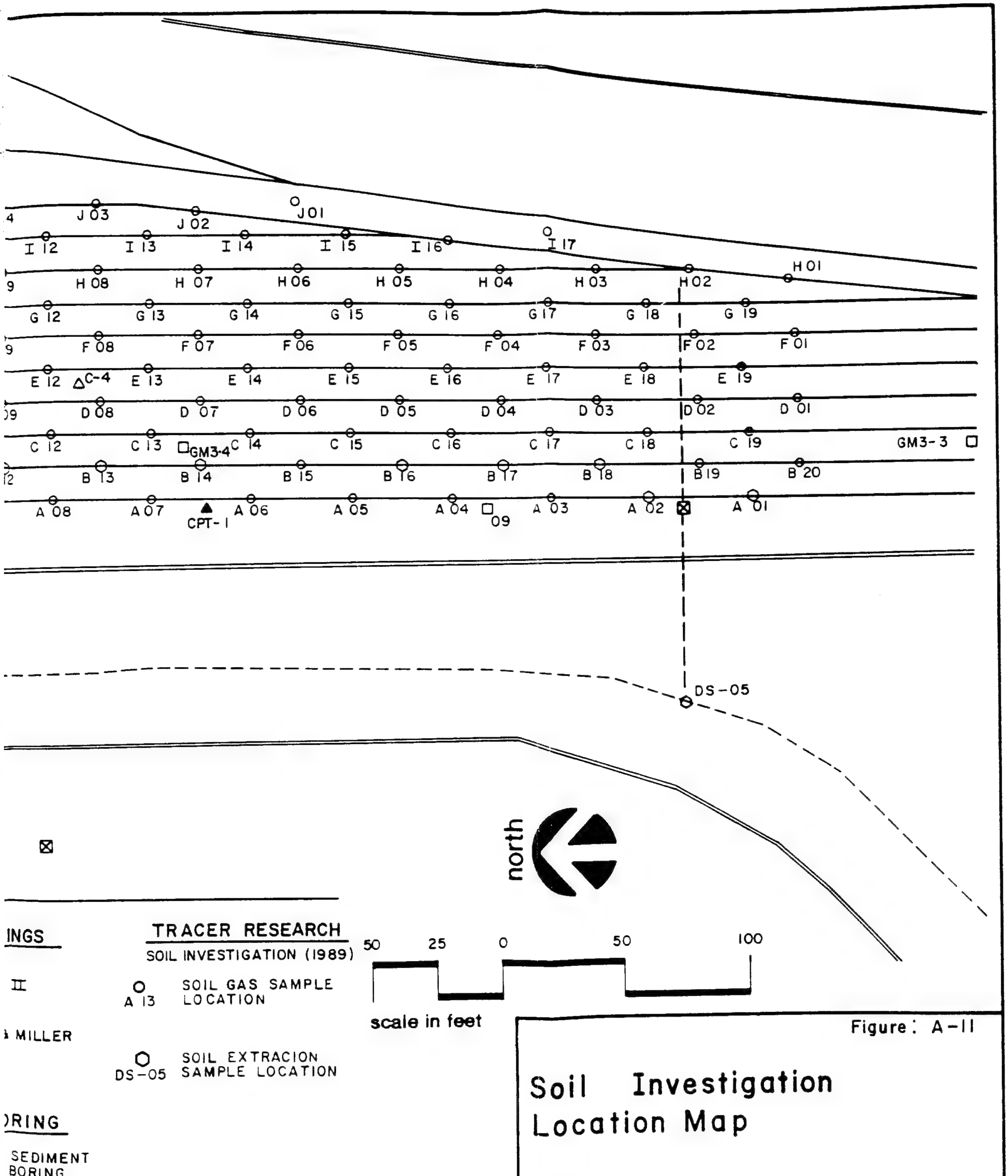
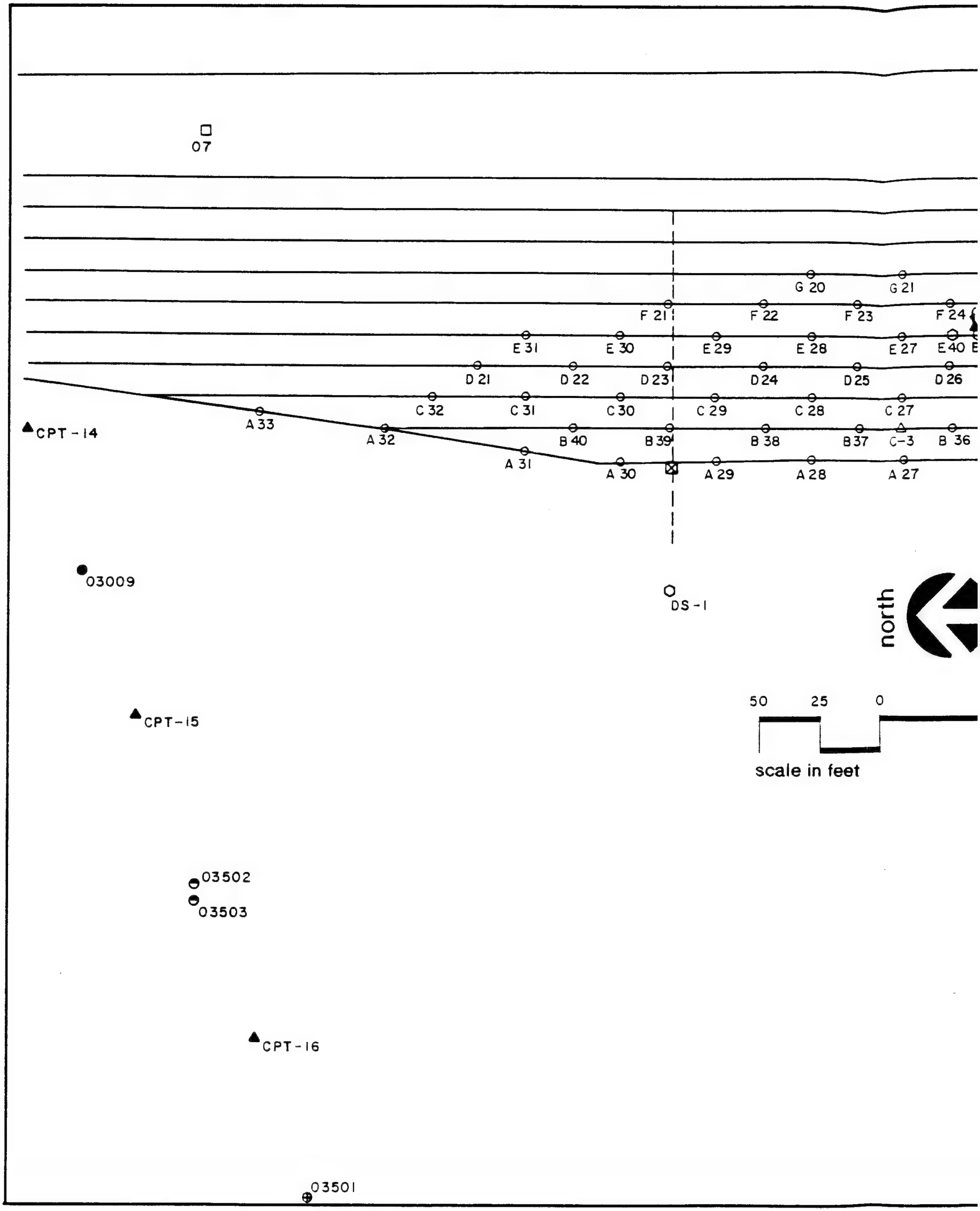


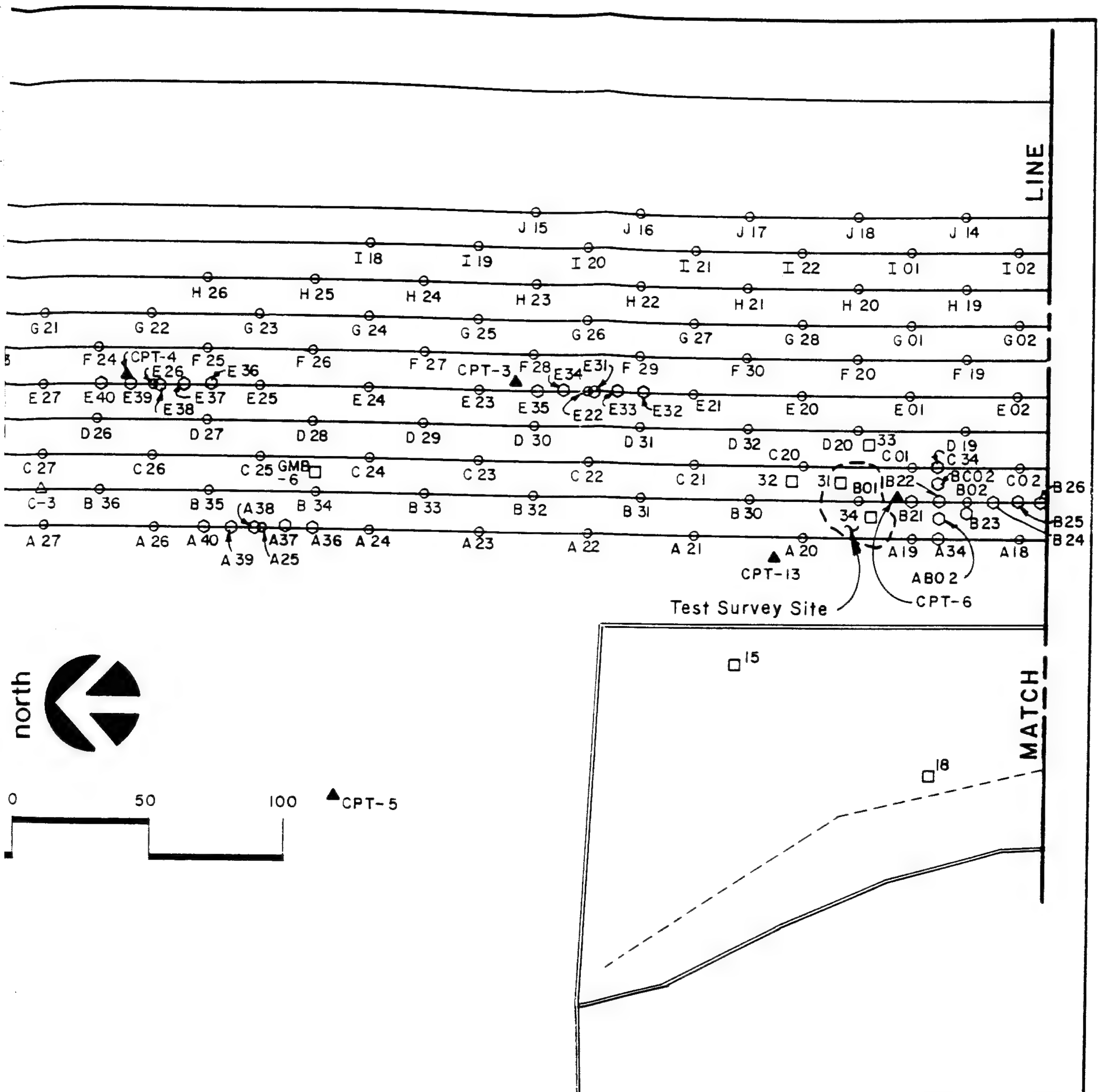
Figure: A-11

Soil Investigation Location Map

Prepared by:

MK-ENVIRONMENTAL SERVICES
A DIVISION OF MK-FERGUSON


07
G 20
G 21
F 21
F 22
F 23
F 24
E 31
E 30
E 29
E 28
E 27
E 40
D 21
D 22
D 23
D 24
D 25
D 26
C 32
C 31
C 30
C 29
C 28
C 27
CPT - 14
A 33
A 32
B 40
B 39
B 38
B 37
C-3
B 36
A 31
A 30
A 29
A 28
A 27
03009
DS - 1
north
50
25
0
scale in feet
CPT - 15
03502
03503
CPT - 16
03501



NOTE:
See Figure A-11 For Legend

Figure: A-12

Soil Investigation Location Map

Prepared by:

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A DIVISION OF MK-FERGUSON

North of the Test Survey Site, twenty-one soil gas concentrations were detected on Tracks 1 through 6. All twenty-one detections had fairly low concentrations. Additional samples collected near three of the soil gas hits also had low concentrations (<0.070 ug/g).

No soil gas or soil extraction samples collected south of CPT-18 or outside of the holding tracks contained detectable DBCP.

2.4.3 Conclusions - Soil Gas Investigation

DBCP was detected in the shallow soil on Tracks 1 through 6 in the railyard. Widespread, low-level contamination is present in the northern part of the railyard; DBCP was not detected south of CPT-18. Although significant surface soil concentrations have been detected only near the Test Survey Site, additional areas of higher concentration of soil contamination that were not detected in this study may exist to the north.

In various investigations, a large number of samples have been collected in the drainage ditch between the tracks and Building 619. No DBCP detections have been made in the ditch near the surface or to a maximum depth of 60 feet (Army Boring 14). Therefore, the ditch is not a probable source of DBCP to the groundwater plume.

3.0 CONCLUSIONS

The results of this and previous investigations indicate that the sources of DBCP to groundwater near the railyard are residual DBCP in soil and sediment within and beneath the railyard holding tracks, which resulted from leaking tankcars or drums that were shipped in boxcars. Based on vertical decreases in concentration of DBCP in the alluvial aquifer, the sources of DBCP to groundwater are located either in the unsaturated zone or in the uppermost portion of the alluvial aquifer.

The contaminated area delineated in the Test Survey Site was the main probable source found in this investigation, although additional sources may exist. Near the Test Survey Site, southwest dipping clayey sand lenses occur at 7, 20, and 45 feet below ground surface. The clayey lenses may have inhibited vertical migration of DBCP, while facilitating lateral migration from the Test Survey Site toward CPT-12.

To the north of the Test Survey Site, many small, widely-spaced, detections of soil contamination were identified. The maximum concentration from soil extraction was 0.07 ug/g. The concentration of groundwater beneath these areas were generally also low (0.1 ug/l or less), possibly indicating that no additional higher concentration sources exist in this area.

Although no sites of soil contamination were detected south of CPT-18, groundwater data indicate that additional sources of groundwater contamination may be present. Small spills may have occurred between soil gas survey grid locations, or residual surface contamination may have been leached leaving little surface expression of residual DBCP at depth.

4.0 REFERENCES

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May, J. H., 1982, Regional Groundwater Study of Rocky Mountain Arsenal, Denver, Colorado: U.S. Army Engineer Waterways Experiment Station.

Morrison-Knudsen Engineers, Inc., 1987, Geology of the RMA, Adams County, Colorado.

Schmertmann, J. H., 1969, Guidelines for Cone Penetration Test, Performance and Design, Federal Highway Administration, Report FHWA-TS-78-209.

Shell Oil Company, May 24, 1989, Remediation of Other Contamination Sources IRA--Railroad Holding Track--Supplemental Letter Technical Plan.

APPENDIX B

Borehole Logs and Well Construction Diagrams

Borehole/Well No. : 03501 **Project/Task No's. :** Railyard/3711

Date Started : 3-8-89 **Date Completed :** 3-14-89

Drilling Inspector : C. Allen

Drilling Company : Arrow

Surveyed Location : N 177,437.49 E 2,173,498.71

Surveyed Elevation : GS 5210.27 ft. TOC 5211.77 ft.

Total Depth Drilled : 113.3 ft.

Static Water Level Depth : TOC, 76.2 ft. 3-29-89

Drilling Type : Hollow Stem Auger

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
					Steel protective casing set in concrete		Ground Surface
					Concrete		Sand, silty; med brn, fne to med grained, moist.
5					Grout		Sand w/ 10% silt; med brn, fne to coarse grained, moist.
							Sand as above; lt to med brn.
10		SPLIT SPOON			Blank 4" PVC sch. 40		Sand; lt to med brn, fne to med grained
							Sand, clayey, silty; med brn.
							Clay, sandy; lt to med brn.
							Clay, sandy; moist.
15							Sand; med brn, v. fne to v. coarse grained.
							Sand, silty w/ few pebbles; dry.
20							Sand w/ 5% pebbles & gravel to ½" dia; lt brn, fne to v coarse grained, dry.
							Sand; fne to coarse grained, dry.
25							Sand w/ 5% gravel to 1" dia; lt brn;

Borehole/Well No. : 03501 **Project/Task No's. :** Railyard/3711

Date Started : 3-8-89 **Date Completed :** 3-14-89

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
					Grout		fne to v. coarse grained, dry.
							Sand and Gravel; dry.
30							Sand w/ 20% Pebbles & Gravel to 1" dia; lt brn, med to v coarse grained, dry.
							Sand & coarse Pebbles; dry.
35							Sand, v. clean; lt brn, fne to med grained, dry.
							Sand, silty; dry.
40		SPLIT SPOON					Sand; lt to med brn, v. fne to med grained, pred. fne, dry.
							Sand, silty; dry.
45							Sand w/ one 2" Gravel; lt brn, med to coarse grained, dry.
							Sand and Pebbles (pea gravel); dry. Tight Clay on bit.
50							Sand, clayey; med to dk brn, v. fne grained, moist.
							Hard drilling, dry, to few cuttings to log, added water for drilling.
							Clay, sandy; dk brn to green, blocky, stiff, moist.
55							Sand; lt brn, v fne to med grained, dry.
							Clay cuttings; hard slow drilling.
60							Sand; lt to med brn, fne to v. coarse Gravel, moist from added water.
							No cuttings.

Borehole/Well No.: 03501 **Project/Task No's.:** Railyard/3711

Date Started: 3-8-89 **Date Completed:** 3-14-89

Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
65		SPLIT SPOON			65.5 Bentonite 66.9 Pellets		Interbedded fne to v coarse, lt brn Sand w/ v fne to fne, med brn Sand w/ 10% Clay. Beds up to 4" thick, dry. No cuttings, added 2 gals of H_2O.
70			75%		68.5 Well Screen 0.02 slot, 4" PVC sch. 40		Sand; lt brn, fne to v. coarse grained, moist to wet, water @ 70'?
							Hard, slow drilling.
75							Sand, silty w/ 5% Pebbles up to 1/4 dia; med brn, fne to v coarse grained, saturated. No cuttings.
80							Sand as above w/ 8% Pebbles, material "cleaner" than above, saturated. No cuttings.
85							Sand w/ 2% Gravel; lt to med brn, fne to coarse Gravel, saturated.
					Bottom Plug 88.5		Sand on inner bit, clayey @ 89'.
90			0		Bentonite Pellets Sand Pack (10-20 Sand)		No recovery, sample fell out of tube, ≈ 2' of sand flowed up hole. Sandy cuttings.
95			0		10" dia hole		No recovery; Sand; med to v coarse grained on outside of tube. Easy drilling; most likely Sand. about 11' of Sand sluffed into hole.
100							Easy drilling, no cuttings, possible Gravel @ 102'.

Borehole/Well No. : 03501 **Project/Task No's. :** Railyard /3711

Date Started : 3-8-89 **Date Completed :** 3-14-89

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
105					Bore Hole infilled from sluff. Probable Sand.		Sand w/ <5% Pebbles, silty; med brn, fne to coarse grained, saturated. Gravel? @ 106'. @ 109' material on inner bit was Sand, silty; fne to v coarse grained, saturated. Gravels @ ~110 to ~112'. Top of Denver @ 112.5' Inner bit had a green to black Claystone.
110							
115							

Borehole/Well No.: 23502 **Project/Task No's.:** Railyard / 3711

Date Started: 3-15-89 **Date Completed:** 3-17-89

Drilling Inspector: C. Allen

Drilling Company: Arrow

Surveyed Location: N 177,486.16 E 2,173,629.69

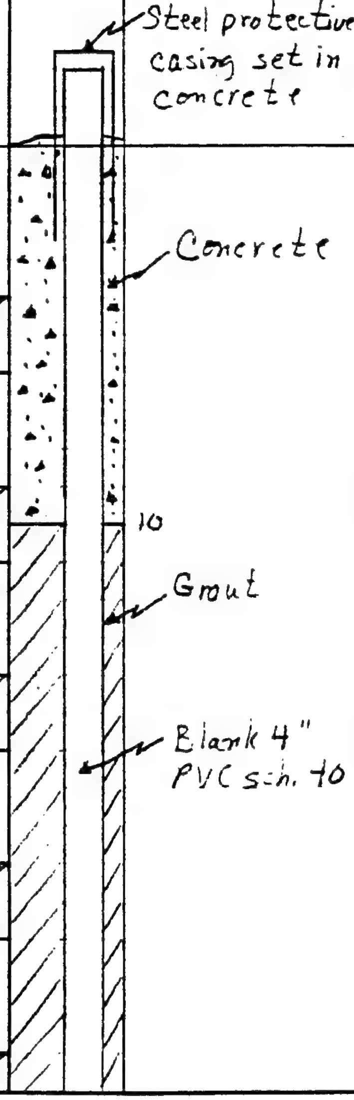
Surveyed Elevation: GS 5208.62 ft. TOC 5210.58 ft.

Total Depth Drilled: 112.0 ft.

Drilling Type: Hollow Stem Auger

Static Water Level Depth: TOC, 75.4 ft. 3-29-89

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description



Ground Surface

Depth (ft.)	Sample Type	Lithologic and Hydrologic Description
0–3	SPLIT SPOON	Sand, silty; lt to med brn, fne to med grained, dry.
3–6		Sand, silty; med brn, fne to v coarse grained, dry.
6–10		Sand, silty; dry
10–11.5		Sand, silty w/ minor Clay; med brn, fne to coarse grained, dry.
11.5–14		Sand, clayey; dry. Slow drilling Sand @ 13'
14–16		Sand w/ 15% Gravel to 1/2" dia; lt brn, fne to v coarse grained, dry.
16–19		Sand & Pebbles.
19–21		Sand w/ <2% Pebbles (clean); lt brn, fne to v coarse grained, dry.
21–24		Sandy cuttings.
24–25		Sand w/ 10% Pebbles to 1/4" dia; tan

Borehole/Well No. : 03502 **Project/Task No's. :** Railyard/3711

Date Started : 3-15-89 **Date Completed :** 3-17-89

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
					Grout		lt brn, fne to v coarse, dry.
							Sandy cuttings; dry.
30							Sand; tan to lt brn, v fne to coarse, dry.
							Sand and pea Gravel.
35							Sand, lower 3" w/ Gravel to 1/2" dia, silty; med brn, v fne to v coarse grained, dry.
							Sandy cuttings.
40							Sand (clean); tan, lt brn, fne to v coarse grained, dry.
							Sandy cuttings; hrd drilling, dry
							Clay?; v. hard. H_2O added 41-44'. softer @ 43.5-44'
45							Sand, clayey; med to dk brn, fne to med grained, moist from added water.
							No cuttings; Slow drilling.
50							Sand, clayey; med brn, fne to med w/ occ coarse grained, dry.
							No cuttings. Hard, slow drilling, water added to hole.
55							Sand, clayey; med brn, fne to v coarse grained, moist from added H_2O.
							No cuttings. Slow drilling, added water to hole.
60							Sand; lt brn, fne to v coarse, moist from added water. Lower 4" is a clayey fne Sand.
							Sandy cuttings. Hard, slow drilling, added water to hole.

Borehole/Well No. : 03502 **Project/Task No's. :** Railyard/3711

Date Started : 3-15-89 **Date Completed :** 3-17-89

Depth Below Ground Surface (ft.)	Blow Count/Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
65		SPLIT SPOON			Grout		Sand, clayey; med brn, v fne to med, stiff. Sand, silty; med brn, fne to med grained. Sand (clean); lt brn, fne to v coarse.
							Sandy cuttings; Added water to hole.
70							Sand, silty w/ 10% Pebbles to 1/4" dia; med brn, fne to v coarse, dry.
							No cuttings; Hard, slow drilling. water @ ~73.5'
75							Sand, silty w/ few Pebbles to 1/4 dia. med brn, fne to v coarse grained, saturated, finer sand @ 75.7-76.0'.
							No cuttings. Easy drilling.
80			0%				No sample, fell out of tube, appear to be a Sand; fne to v coarse. sand flowed up augers ~6'.
							Sandy cuttings; saturated
85			0%		84.8 Bentonite Pellets		No recovery, fell out of tube, appears to be a Sand; fne to v coarse.
							Sandy cutting, Sand, silty; v fne to coarse on inner bit. Easy drilling.
90			5%				No recovery, fell out of tube, appears to be a Sand; fne to med.
					93.4		Sandy cuttings; saturated. Sand flowed up augers ~7'.
95					Sand Pack (10-20 sand)		Sandy cuttings; Sand, silty, w/ few Pebbles to 1/4" dia; fne to v. coarse grained on inner bit. Easy drilling.
100			0%		101.2		No recovery, appears to be a Sand, silty; v fne to coarse grained.
							Sandy cuttings w/ some Gravels; saturated. Easy drilling.

Borehole/Well No. : 03502 **Project/Task No's. :** Railyard/3711

Date Started : 3-15-89 **Date Completed :** 3-17-89

Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
105		SPLIT SPOON			Well Screen 0.02 slot, 4" PVC sch 40 w/ bottom plug		Gravels & Cobbles @ ~105 to 108.
			0%				No recovery, appears to be a Sand; fine to coarse grained, flowed up auger ~5'.
110							Top of Denver @ 109.5' Black Shale on inner bit; dry.
					111.2		
115							

Page No. : 4 of 4

Borehole/Well No. : 03503 **Project/Task No's. :** Railyard/3711

Date Started : 3-20-89 **Date Completed :** 3-21-89

Drilling Inspector : C. Allen

Drilling Company : Arrow

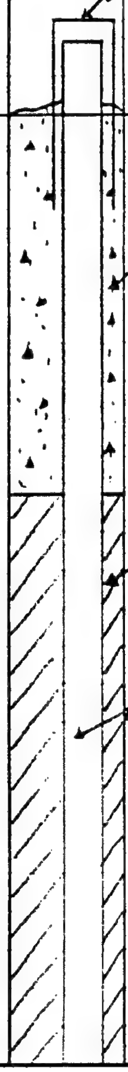
Surveyed Location : N 177,486.39 E 2,173,622.96

Surveyed Elevation : GS 5208.58 ft. TOC 5210.48 ft.

Total Depth Drilled : 92.0 ft.

Drilling Type : Hollow Stem Auger

Static Water Level Depth : TOC, 75.2 ft. 3-29-89

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
					Steel protective casing set in concrete		
							Ground Surface
					Concrete		NOTE: See Well 03502 for lithologic description. Wells 03502 and 03503 are located approx. 7 ft apart.
5							
10					Grout		
15					Blank 4" PVC sch. 40		
20							
25							

Borehole/Well No. : 03503 **Project/Task No's. :** Railyard/3711

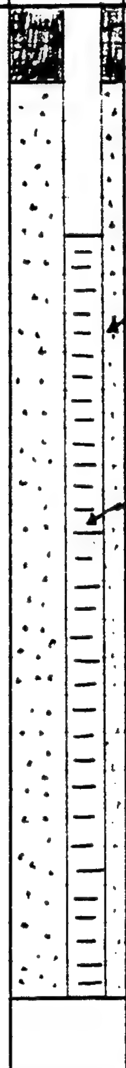
Date Started : 3-20-89 **Date Completed :** 3-21-89

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
30					Grout		NOTE: See Well 03502 for lithologic description. Wells 03502 & 03503 are located approx. 7 ft apart.
35							
40							
45							
50							
55							
60							
					63.5		

Borehole/Well No. : 03503 **Project/Task No's. :** Railyard /3711

Date Started : 3-20-89 **Date Completed :** 3-21-89

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
65					Bentonite Pellets		NOTE: See Well 03502 for lithologic description. Wells 03502 and 03503 are located approx. 7 ft apart.
					66		
70					70		
					Sand Pack w/ some natural infill. (10-20 sand)		
75							
					Well Screen 0.02 slot, 4" PVC sch. 40		
80							
85							
					10" dia hole		
					Bottom Plug		
90					90 Hole sluffed from 90 to 92 ft		
95							



Borehole/Well No. : 03504 **Project/Task No's. :** Railyard / 3711

Date Started : 3-2-89 **Date Completed :** 3-7-89

Drilling Inspector : C. Allen

Drilling Company : Arrow

Surveyed Location : N 175,940.76 E 2,173,917.83

Surveyed Elevation : GS 5210.82 ft. TOC 5212.77 ft.

Total Depth Drilled : 70.0 ft.

Drilling Type : Hollow Stem Auger

Static Water Level Depth : TOC, 56.0 ft. 3-29-89

Sample Information: Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Construction: Well Schematic	Material Description	Subsurface Information: Borehole Schematic	Lithologic and Hydrologic Description
					Steel protective casing set in concrete		
							Ground Surface
					Concrete		3" of Asphalt @ surface Sand, silty; med brn, v. fne to fne grained.
5				3.5	Grout		Sand, silty; lt to med brn, v fne to fne grained, moist to dry, clayey @ 5.2-6.0'. Sand, clayey; lt brn, moist.
10		SPLIT SPOON			Blank 4" PVC sch.40		Sand (clean); lt brn, v. fne to med grained, moist, qtz, hornblende & Feldspar? Sand (clean), @ 12' Gravel & Cobbles coming up w/ cuttings.
15							Sand w/ 10% Gravel & Cobbles to 1/2" dia; lt brn, v fne to coarse, sl moist to dry. Sand, silty w/ few Gravels; lt to med brn.
20							Sand w/ <5% silt & w/ 10% Gravel & Pebbles to 1/2" dia. lt brn, fne to coarse grained, sl moist to dry. Sand w/ Pebbles, silty.
25							Sand as in 19-21' sample, Gravel &

Borehole/Well No. : 03504 **Project/Task No's. :** [illegible]/3711

Date Started : 3-2-89 **Date Completed :** 3-7-89

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
							Pebbles to 1" dia; dry.
							Sand, silty w/ abdnt Pebbles; dry.
					Grout		Sand as above; dry.
30							Sand, silty, clayey; med brn, v fne grained, dry.
							Sand, silty w/ few Gravels; dry.
							Sand (clean); lt brn, fne to med grained, sli moist to dry.
35							Sand, silty; dry. Added H2O to hole.
					10" dia hole to 68'; 2 5/8" dia hole @ 68 to 70'		Sand; lt brn, fne to coarse grained, sli moist from added H2O.
40		SPLIT SPOON					Sand w/ few Gravels which increase w/ depth; dry.
					44.3 Bentonite Pellets 45.7		Sand w/ 10% Gravels & Pebbles to 1/2" dia; lt brn, fne to coarse grained, sli moist.
45							Sand w/ Gravels & Pebbles; brn, dry.
					48.2		Sand w/ < 5% Pebbles; lt to med brn, fne to coarse, sli moist.
50					Sand Pack (10-20 Sand)		Sand, silty w/ 10% Pebbles; dry. Hrd, slow drilling.
					Well Screen 0.02 slot, 4" PVC sch. 40		Sand w/ < 5% Silt & [illegible]% Gravels to 1 1/2" dia; lt brn, fne to coarse grained, saturated.
55							Sandy cuttings; saturated.
							Sand, silty w/ few Gravels to 1 1/2" dia; vfne to med grained, saturated.
60							Sand, silty, clayey; med brn, [illegible] grained, saturated.
							No cuttings; clayey Sand?
							No cuttings; Sand & Gravel?
							Lost Sample; from material [illegible]

Page No. : 2 of 3

Borehole/Well No. : 03504 **Project/Task No's. :** Rubert / [illegible]711

Date Started : 3-2-89 **Date Completed :** 3-7-89

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
65		SPLIT SPOON	0%				split spoon appeared to be clean Sand. Sandy cuttings; saturated
					68.2		Sand; fine to coarse, saturated. Top of Denver @ 68.2'
70					Bottom Cap		Claystone w/ tr Sand (<2%); lt green to brn, blocky, fribble, WX w/ Fe and manganese staining, saturated.

Borehole/Well No. : 03505 **Project/Task No's. :** Railyard /3711

Date Started : 3-22-89 **Date Completed :** 3-23-89

Drilling Inspector : C. Allen

Drilling Company : Arrow

Surveyed Location : N 177,399.00 E 2,173,354.69

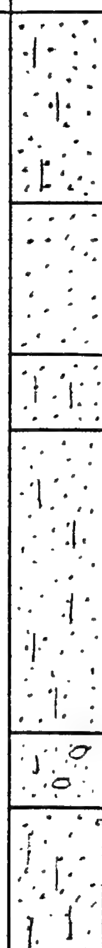
Surveyed Elevation : GS 5203.43 ft. TOC 5205.82 ft.

Total Depth Drilled : 167.0 ft.

Drilling Type : Hollow Stem Auger

Static Water Level Depth : TOC, 70.0 ft. 3-29-89

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
					Steel Protective casing set in concrete		
							Ground Surface
					Concrete		Sand, silty; dk brn, v fne grained, moist
5					6.0 Grout		Sand as above w/ size increasing to v coarse.
10		SPLIT SPOON					Sand, silty; lt to med brn, v fne to coarse grained, dry.
					Blank 4" PVC sch 40.		Sand, silty; med brn, dry.
15							
20							Sand w/ ~10% Gravel to ½ dia, minor silt; lt brn, v fne to coarse grained, dry.
							Sand, silty; lt to med brn, dry.
25							



Borehole/Well No. : 03505 **Project/Task No's. :** Railyard/3711

Date Started : 3-22-89 **Date Completed :** 3-23-89

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
30		SPLIT SPOON			Grout		Sand w/minor silt; lt brn, v. fine to v. coarse grained, dry.
							Sand, silty med brn, fine to v coarse grained, dry
35							
40							Sand, silty; med brn, fine to coarse grained, dry.
							Sand (clean); lt brn to white, v fine to coarse grained, dry.
45							Sand, silty; med brn, v fine to v coarse grained; dry.
50							Sand w/minor silt, (clean); lt brn to white, v fine to v coarse grained, dry.
							Sand, silty; hard drilling.
55							
60							Sand, silty w/20% gravel to 1/4 to 1 1/2" dia; lt to med brn, [illegible] to v coarse grained, dry.
					[illegible] Bentonite Pellets		Hard [illegible] drilling [illegible] 59 ft.
					63.9		[illegible]

Borehole/Well No. : 13505 **Project/Task No's. :** Railyard/3711

Date Started : 3-22-89 **Date Completed :** 3-23-89

Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
65					65.6		water @ ~68'
70		SPLIT SPOON			Well Screen 0.03 slot, 4" PVC sch. 40		Sand, silty w/ 20% Gravel 1/4" to 1/2" dia; med brn, fine to v coarse grained, saturated.
75					Sand Pack (8-12 sand)		from drilling appears to be Sand.
80					10" dia hole		@ 79' while pulling inner bit, ~5 ft sand flowed up augers, very similar to other wells drilled in this area. Most [illegible] saturated Sand; fine to v coarse grained
85							@ 81 to 89 easy drilling Sandy; saturated.
90							@ 89' while pulling inner bit, ~10 ft sand flowed up [illegible] Sand, v coarse grained.
							Sandy cuttings; saturated. @~91-94' Cobbles-Gravel up to 1" dia.
95							Sandy cuttings w/ Cobbles; saturated
							sand flowed up augers.
100							Sand and Cobbles up to 1 1/2" dia.

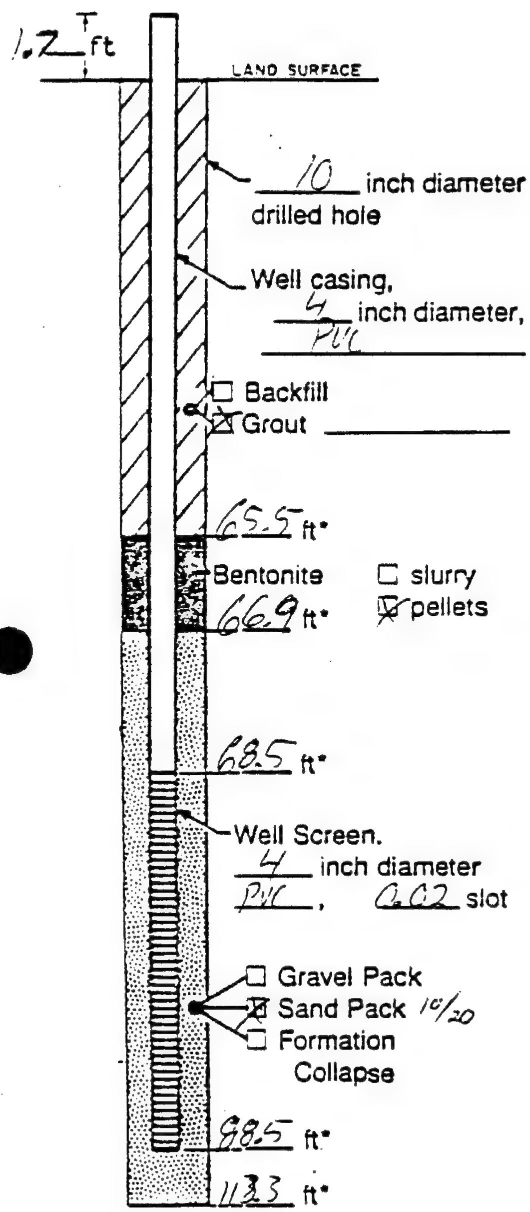
Borehole/Well No. : 03505 **Project/Task No's. :** Railyard/3711

Date Started : 3-22-89 **Date Completed :** 3-23-89

Sample Information: Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Construction: Well Schematic	Material Description	Subsurface Information: Borehole Schematic	Lithologic and Hydrologic Description
105					105.6 106.6 12" adapter @ 105.6-106.6' w/ bottom plug		Top of Denver @ ~ 106 Shale; green to black. NOTE: when pulled inner bit and rods, Sand flowed into hole to 81 ft.
110							

3711.01.01

WELL CONSTRUCTION LOG



Measuring Point is Top of Well Casing Unless Otherwise Noted.

*Depth Below Land Surface

Project RMA Well #03501

Town/City Commerce City

County Adams State CO

Permit No. —

Land-Surface Elevation and Datum 5210 feet ☐ surveyed ☒ estimated

Installation Dates(s) 3/8/89 – 3/14/89

Drilling Method Hollow Stem Auger

Drilling Contractor Arrow Drilling

Drilling Fluid —

Development Techniques(s) and Date(s)

Surge / Bail

Fluid Loss During Drilling — gallons

Water Removed During Development 125 gallons

Static Depth to Water 26.2 feet below M.P.

Pumping Depth to Water — feet below M.P.

Pumping Duration — hours

Yield — gpm Date 3/29/89

Specific Capacity — gpm/ft

Well Purpose

Monitoring

Remarks

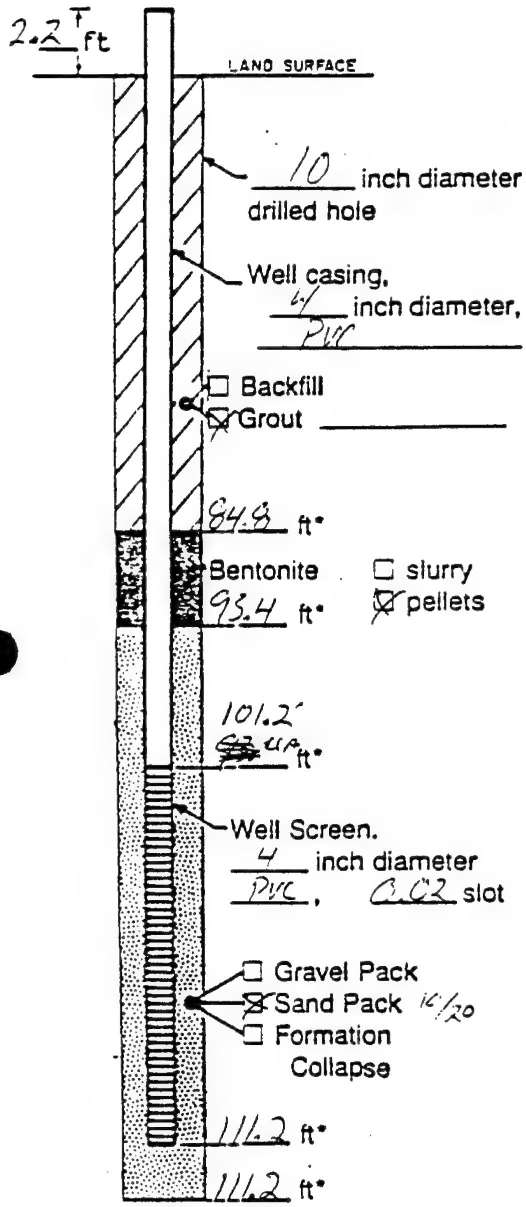
Sand + infilling

Fm. to 90' bentonite to 89'

Sand to 88.5'

Prepared by C. All

WELL CONSTRUCTION LOG



Measuring Point is Top of Well Casing Unless Otherwise Noted.

*Depth Below Land Surface

Project RMA Well C3502

Town/City Commerce City

County Adams State CO

Permit No. —

Land-Surface Elevation and Datum 5209 feet ☐ surveyed ☒ estimated

Installation Dates(s) 3/15/89 – 3/17/89

Drilling Method Hollow Stem Auger

Drilling Contractor Arrow Drilling

Drilling Fluid —

Development Techniques(s) and Date(s)

Surge / Bail

Fluid Loss During Drilling — gallons

Water Removed During Development 225 gallons

Static Depth to Water 75.4 feet below M.P.

Pumping Depth to Water — feet below M.P.

Pumping Duration — hours

Yield — gpm Date 3/29/89

Specific Capacity — gpm/ft

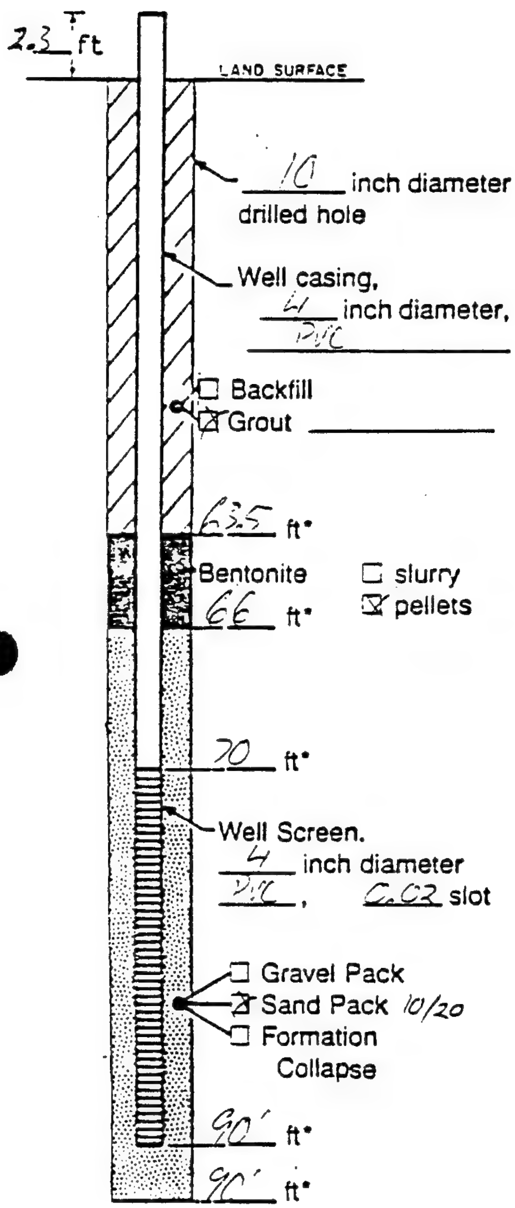
Well Purpose

Monitoring

Remarks

Prepared by [signature]

WELL CONSTRUCTION LOG



Measuring Point is Top of Well Casing Unless Otherwise Noted.

*Depth Below Land Surface

Project RMA Well C3503

Town/City Commerce City

County Adams State CO

Permit No. ______

Land-Surface Elevation and Datum 5209 feet ☐ surveyed ☒ estimated

Installation Dates(s) 3/17/89 -

Drilling Method Hollow Stem Auger

Drilling Contractor Grow Drilling

Drilling Fluid ——

Development Techniques(s) and Date(s)

Surge / Bail

Fluid Loss During Drilling —— gallons

Water Removed During Development 150 gallons

Static Depth to Water 75.2 feet below M.P.

Pumping Depth to Water —— feet below M.P.

Pumping Duration —— hours

Yield —— gpm Date 3/29/89

Specific Capacity —— gpm/ft

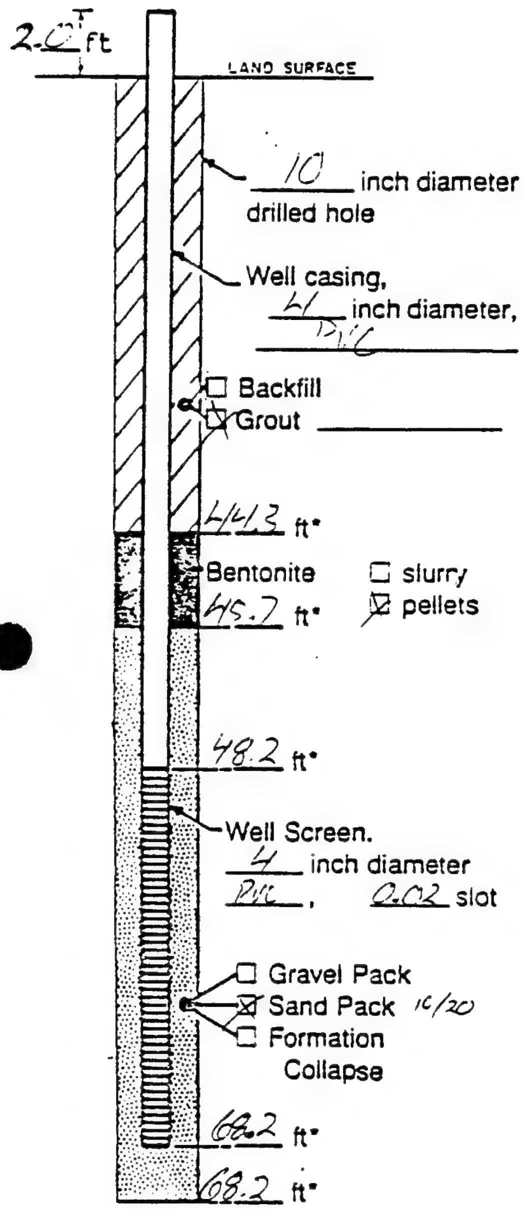
Well Purpose

Monitoring

Remarks ______

Prepared by [signature]

WELL CONSTRUCTION LOG



Measuring Point is Top of Well Casing Unless Otherwise Noted.

*Depth Below Land Surface

Project: RMA Well: 03504

Town/City: Commerce City

County: Adams State: CO

Permit No.: —

Land-Surface Elevation and Datum: 5211 feet ☐ surveyed ☒ estimated

Installation Dates(s): 3/2/89 - 3/3/89

Drilling Method: Hollow Stem Auger

Drilling Contractor: Arrow Drilling

Drilling Fluid:

Development Techniques(s) and Date(s): Surge/Bail

Fluid Loss During Drilling: — gallons

Water Removed During Development: 150 gallons

Static Depth to Water: 56.0 feet below M.P.

Pumping Depth to Water: — feet below M.P.

Pumping Duration: — hours

Yield: — gpm Date: 3/29/89

Specific Capacity: — gpm/ft

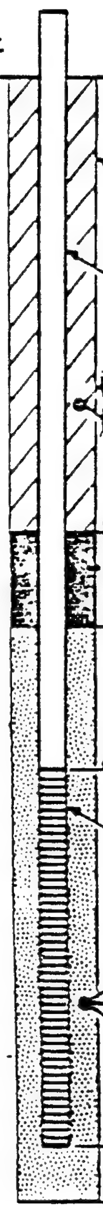
Well Purpose: Monitoring

Remarks:

Prepared by: [illegible signature]

3711.01.01

WELL CONSTRUCTION LOG



2.5 ft

LAND SURFACE

10 inch diameter drilled hole

Well casing, 4 inch diameter, PVC

☐ Backfill
☒ Grout ______

61.7 ft*

Bentonite ☐ slurry ☒ pellets

63.9 ft*

65.6 ft*

Well Screen. 4 inch diameter PVC, ~~0.015~~ slot 0.03

☐ Gravel Pack
☒ Sand Pack 8/12
☐ Formation Collapse

106.6 ft*

106.6 ft*

Measuring Point is Top of Well Casing Unless Otherwise Noted.

*Depth Below Land Surface

Project: RMA Well: 035055

Town/City: Commerce City

County: Adams State: CO

Permit No.: —

Land-Surface Elevation and Datum: 5200 feet ☐ surveyed ☒ estimated

Installation Dates(s): 2/22/89 – 2/23/89

Drilling Method: Hollow Stem Auger

Drilling Contractor: Arrow Drilling

Drilling Fluid: —

Development Techniques(s) and Date(s): Surge / Bail

Fluid Loss During Drilling: — gallons

Water Removed During Development: 350 gallons

Static Depth to Water: 70.0 feet below M.P.

Pumping Depth to Water: — feet below M.P.

Pumping Duration: — hours

Yield: — gpm Date: 3/29/89

Specific Capacity: — gpm/ft

Well Purpose: Injection Test / Monitoring

Remarks:

Prepared by: [signature]

SHELL/MKE SHT. SED. SAMPLING PROGRM.

RCY2BR

approx. coords.
N 175810
E 2173725
(30 FT ± N. OF 33E23

DEPTH BELOW GROUND SURFACE (FEET)	SAMPLE DEPTH INTERVAL	SAMPLE TYPE	PERCENT SAMPLE RECOVERY	DEPTH TO CHANGE IN [illegible] TEXTURE	BOREHOLE SCHEMATIC	MATERIAL DESCRIPTION
0						brown, slightly moist, silty sand; grading downward to clayey silt with minor amount fine sand
				4.5		
5						brown, slightly moist, silty sand with minor amount of clay
10						
				14		
15						brown, slightly moist, silty sand with minor amount of clay; grading downward to clayey sand with minor amount of silt and gravel; gravel clasts disseminated, generally sub-angular rounded, 1/4" diam
				19		
20				20		brown, slightly moist, clayey sand with disseminated gravel; gravel clasts generally rounded to subangular, 1/4" - 1" diameter
				24		brown, slightly moist, silty sand
25						brown, slightly moist, silty sand with minor amount of clay and gravel; gravel decreases with depth through interval, with rounded to subangular clasts up to 2" diameter in upper portion and small sized clasts in lower portion.
30						
				34		
35						

DEPTH BELOW GROUND SURFACE (FEET)	SAMPLE DEPTH INTERVAL	SAMPLE TYPE	PERCENT SAMPLE RECOVERY	K (FT/DAY)	DEPTH TO CHANGE IN COMPOSITION TEXTURE	BOREHOLE SCHEMATIC	MATERIAL DESCRIPTION
35							brown, slightly moist sand with minor amount of clay; abundant gravel clasts varying in diameter from 1/8" - 3/4"
					39		
40							brown, silty sand
					44		
45							brown, slightly moist, clayey sand; grading downward to a sandy clay
50							
					54		
55							brown, silty clay with minor amount of sand
60	60.0	P	50	1.3'	61	▽ 61.5	brown, sand; predominantly coarse-grained; minor amount of gravel
	62.0	B	100				
	64.0						
65	65.0	P	50	5.2'			
	67.0	B	100				
	69.0				69		
70							

Depth	Sample interval	Type	Recovery		Description
70	70.0–72.0	P	0		brown, silty sand; grading downward to coarse sand with minor amount of silt
	72.0–74.0	B	100		
75	75.0–77.0	B	100		
	77.0–79.0	P	100	58.57	(compaction occurred for samples collected above 75' depth)
80					
					TOTAL DEPTH = 79.0 FT
85					
90					
95					
100					
105					

COLORADO ANALYTICAL LABORATORY

SOIL WATER ENVIRONMENTAL

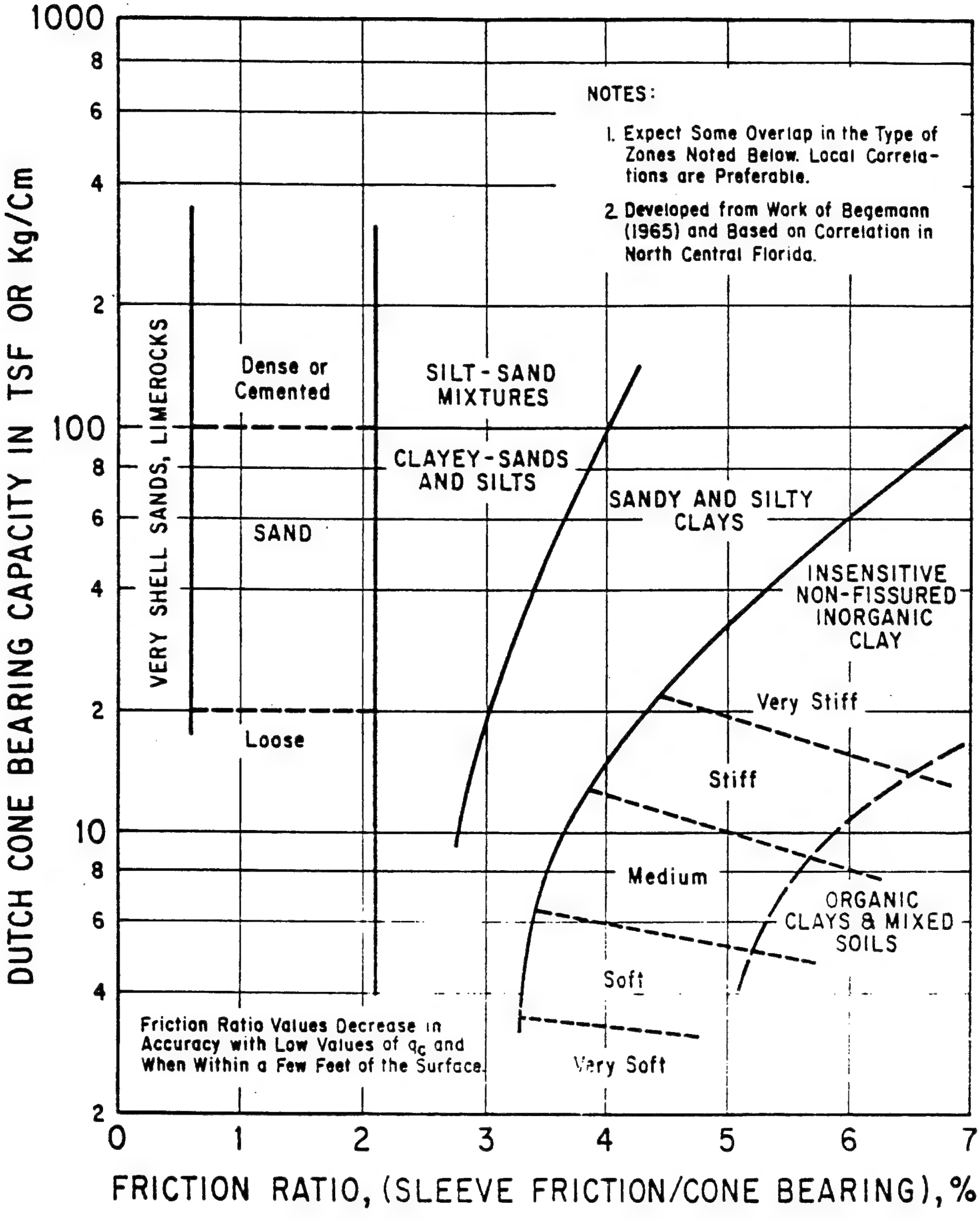
Sample ID	Sand (%)	Silt (%)	Clay (%)	Very Fine Sand (%)	K (cm/hr)	CM/sec
RCY 2BR-P 60/62	63	21	16	4	1.68	4.66×10^{-4}
RCY 2BR-P 65/67	84	8	8	2	65.11	1.8×10^{-2}
RCY 2BR-P 77/79	88	6	6	6	74.39	2.1×10^{-2}
Duplicate :						
RCY 2BR-P 60/62	65	25	10	9	1.73	

240 S. Main Street • Brighton, Colorado 80601 • (303) 659-2313
Mailing Address: P.O. Drawer 507, Brighton, CO 80601

APPENDIX C

Cone Penetration Test Interpretive Chart and Lithologic Profiles

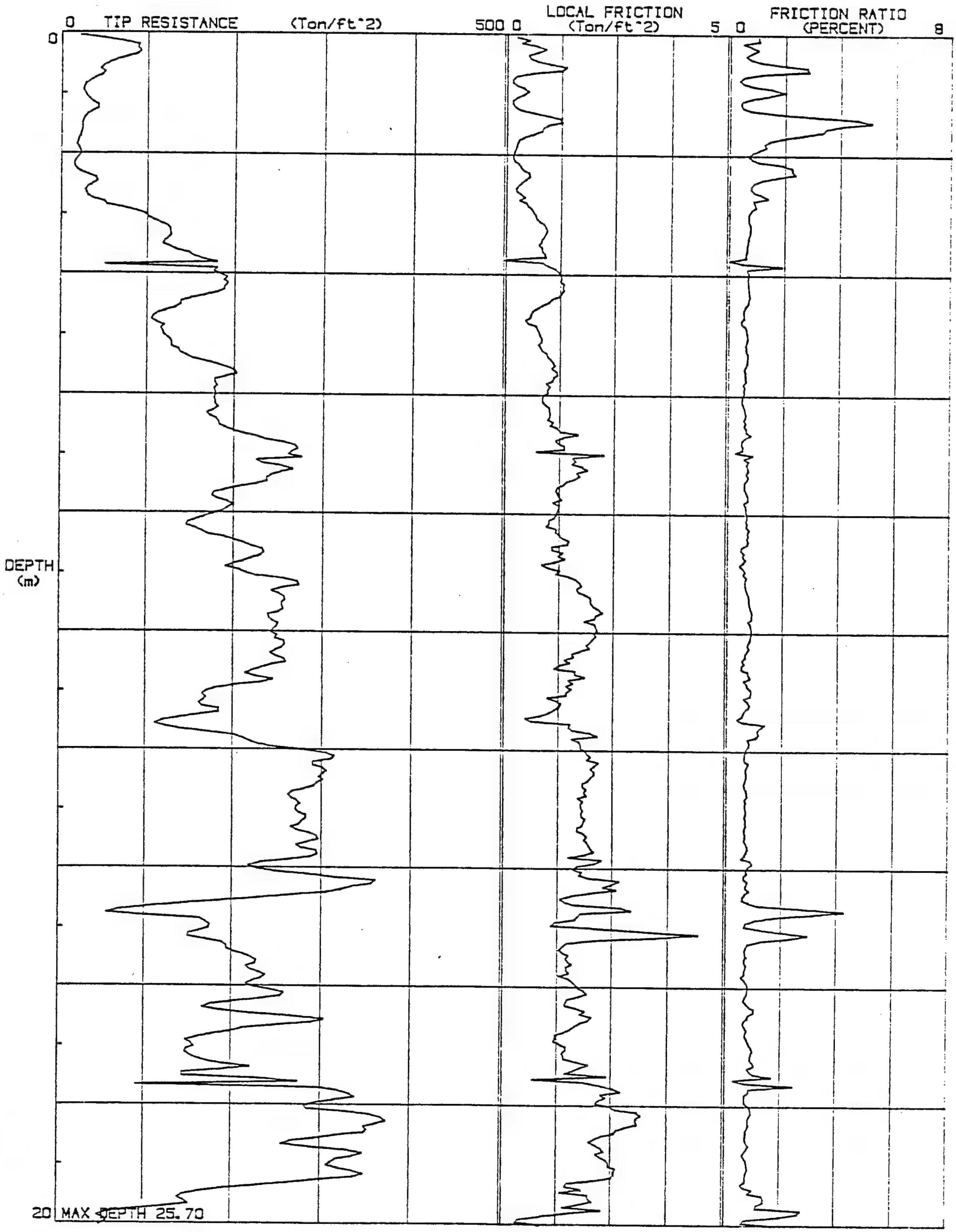
08/17/89



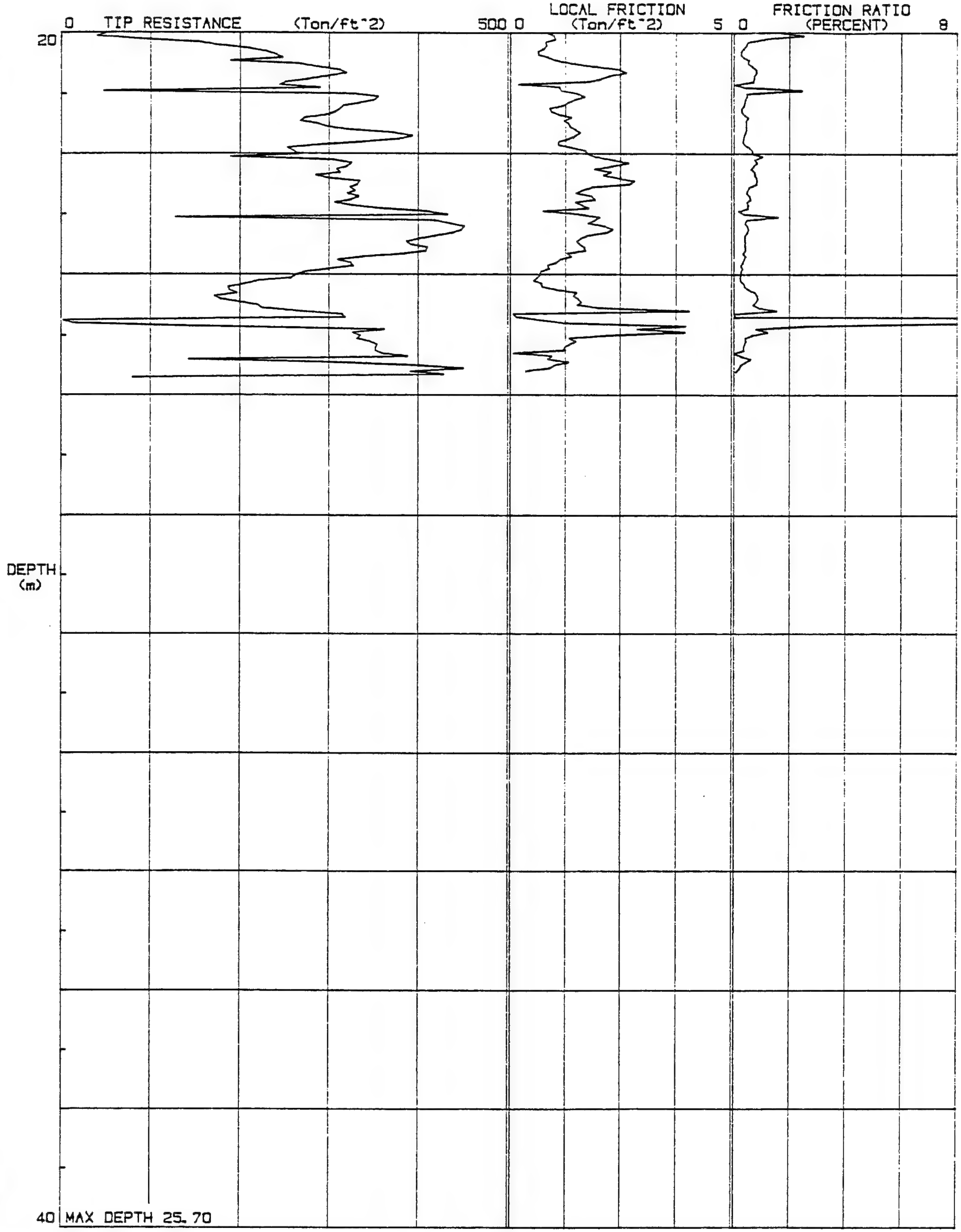
GUIDE FOR ESTIMATING SOIL TYPE FROM DUTCH FRICTION-CONE RATIO (BEGEMANN MECHANICAL TIP)

(AFTER SCHMERTMANN, 1969)

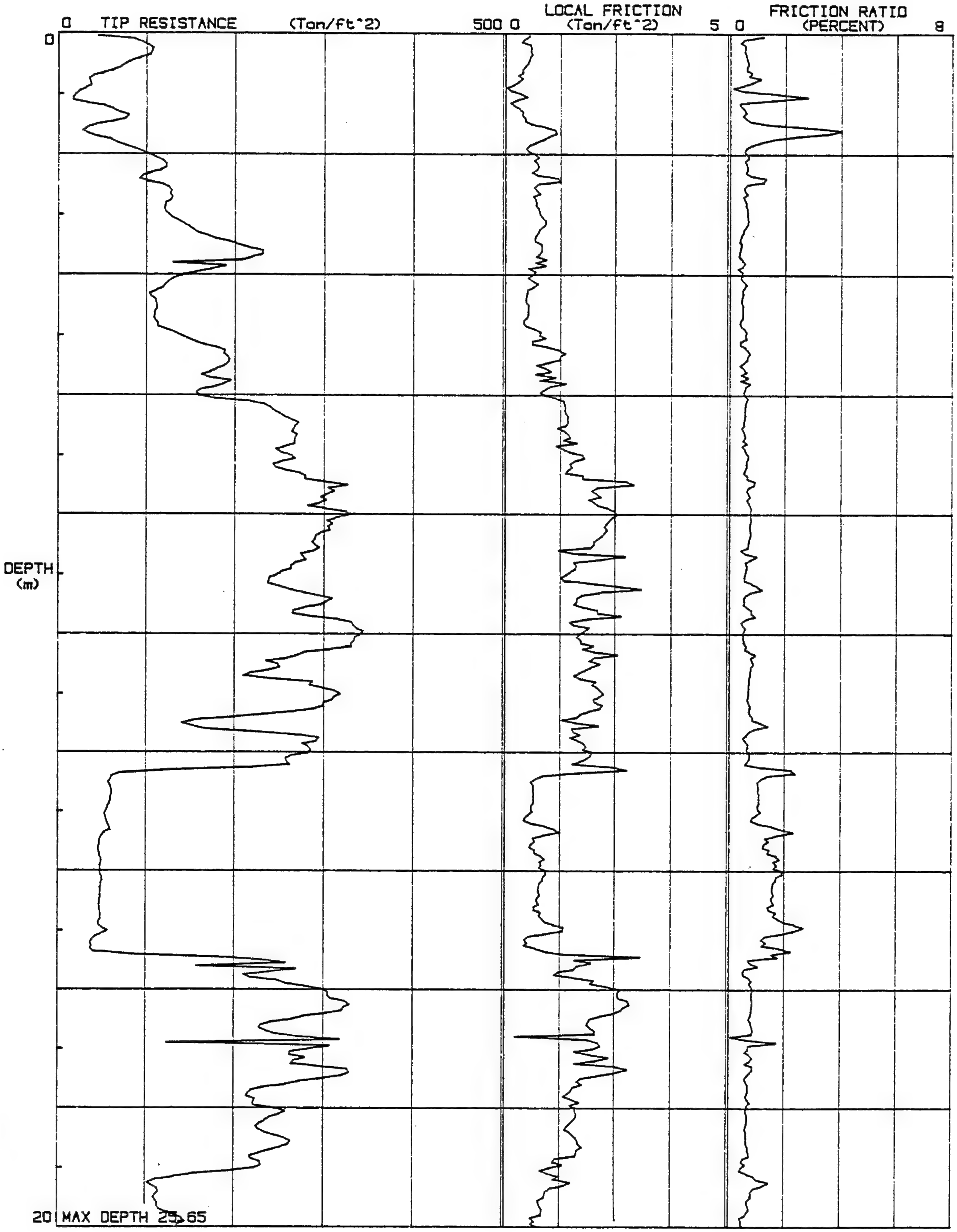
JOB # : 89-1024
DATE : 06-23-89
LOCATION : CPT-1
FILE # : 4



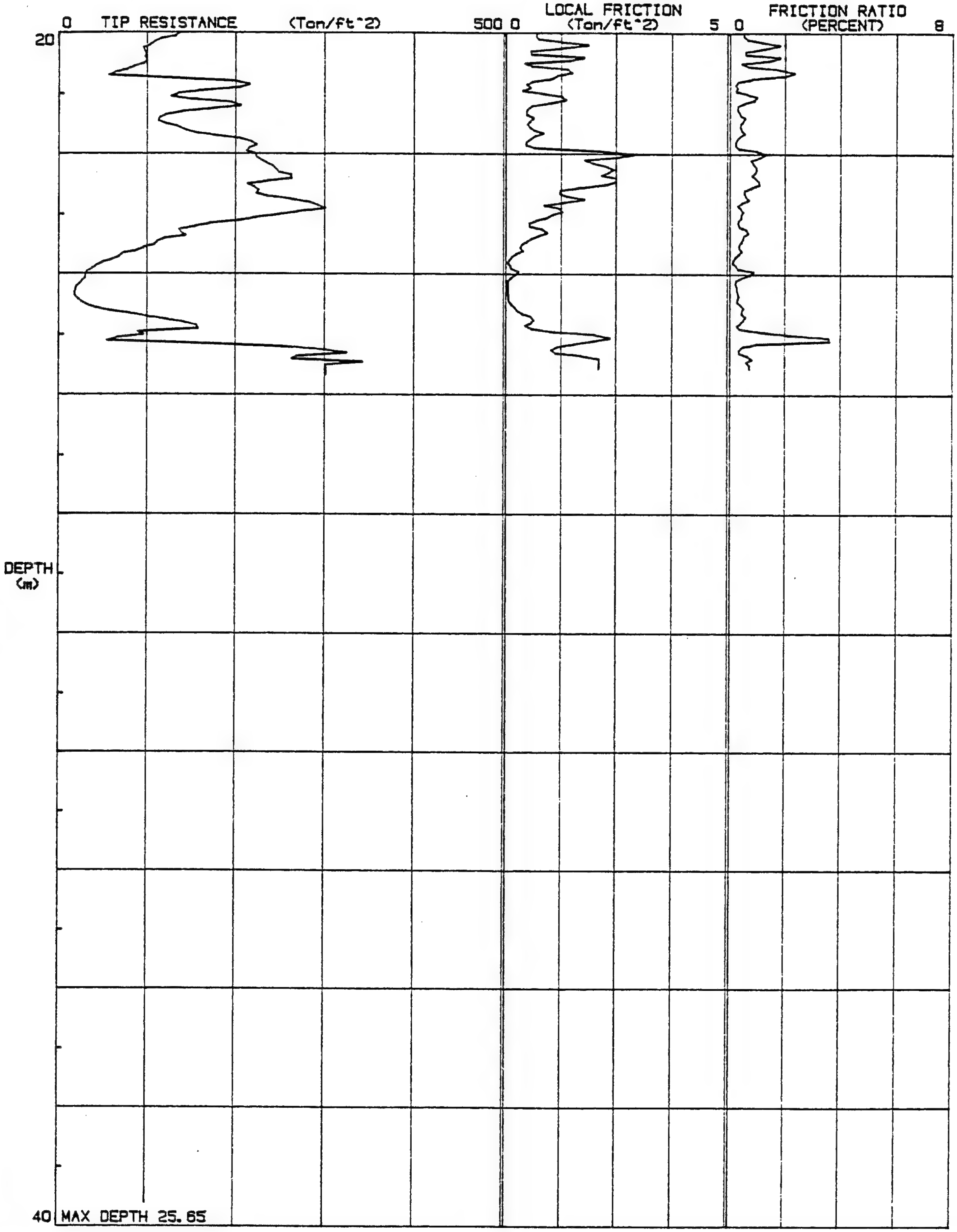
DATE : 06-23-89
LOCATION : CPT-1
FILE # : 4



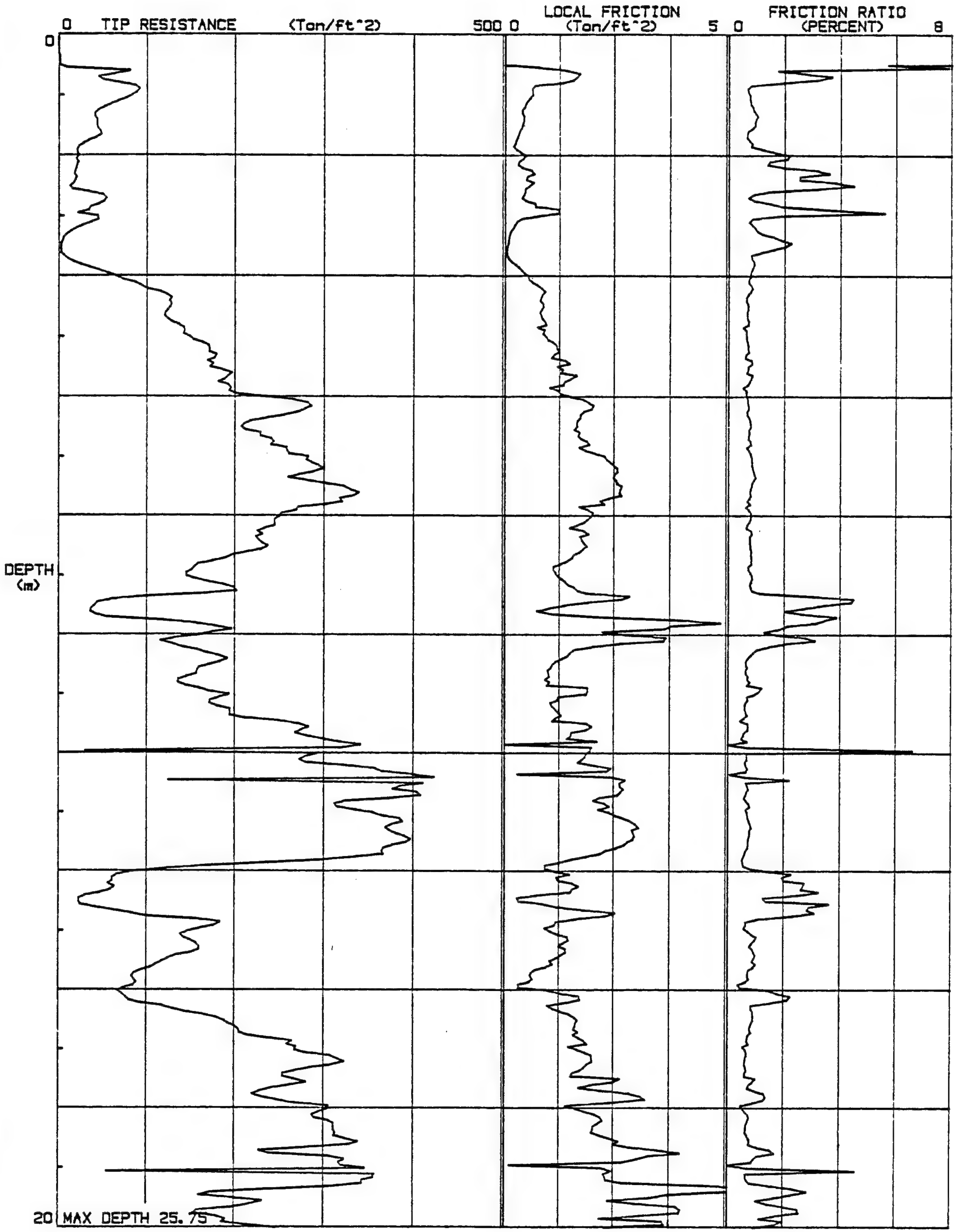
JOB # : 89-1024
DATE : 06-23-89
LOCATION : CPT-2
FILE # : 5



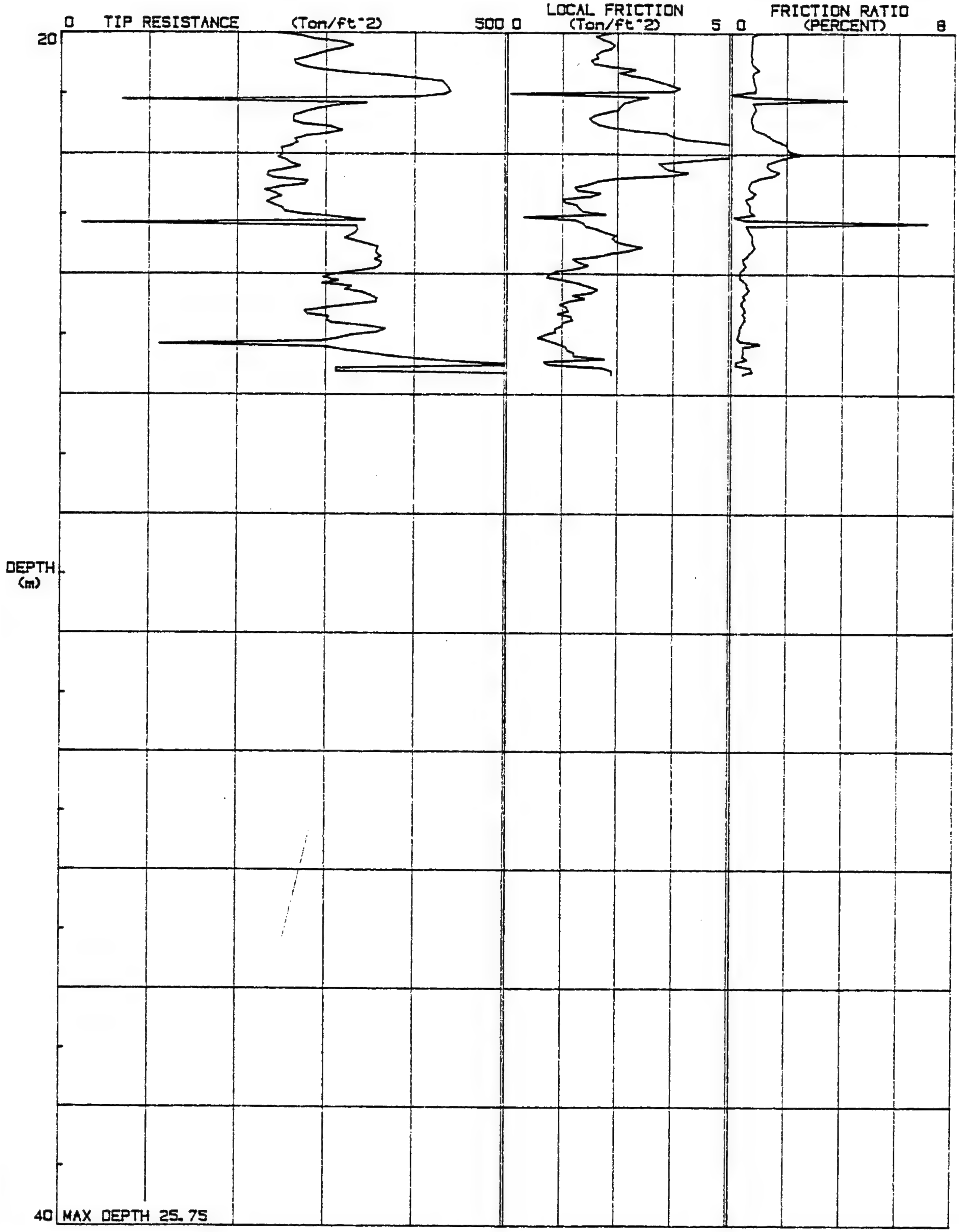
DATE : 06-23-89
LOCATION : CPT-2
FILE # : 5



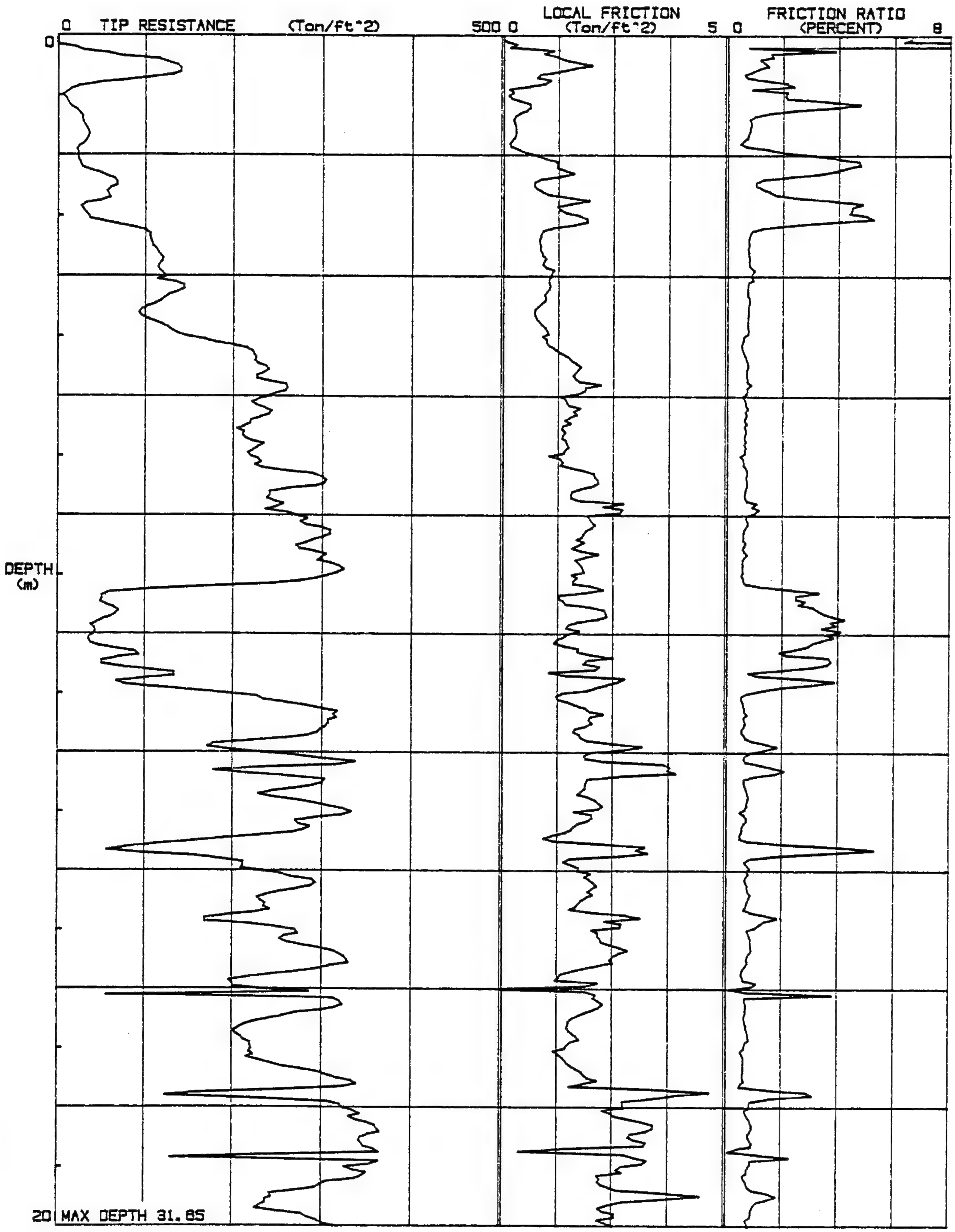
JOB # : 89-1024
DATE : 08-24-89
LOCATION : CPT3
FILE # : 8



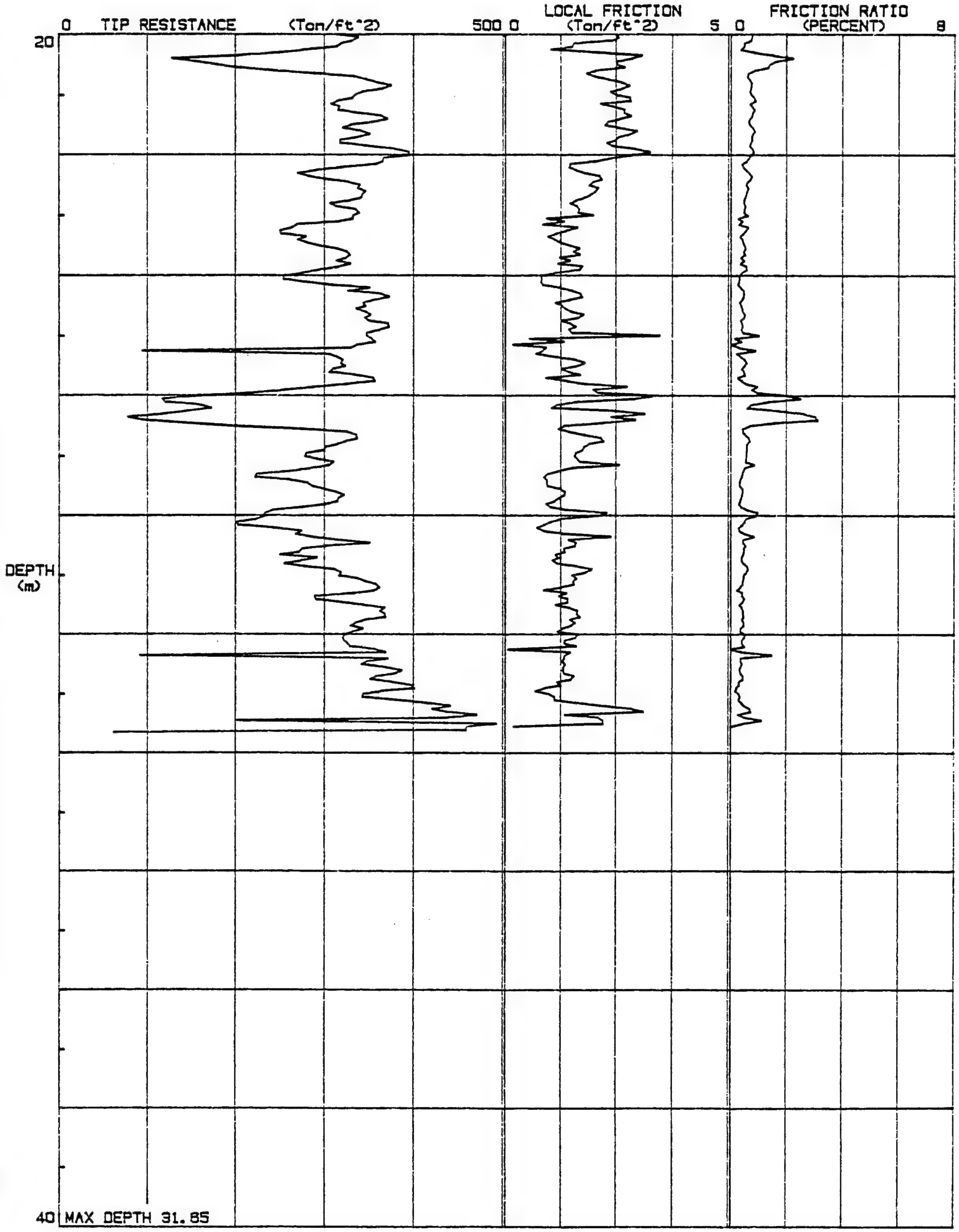
DATE : 08-24-89
LOCATION : CPT3
FILE # : 8

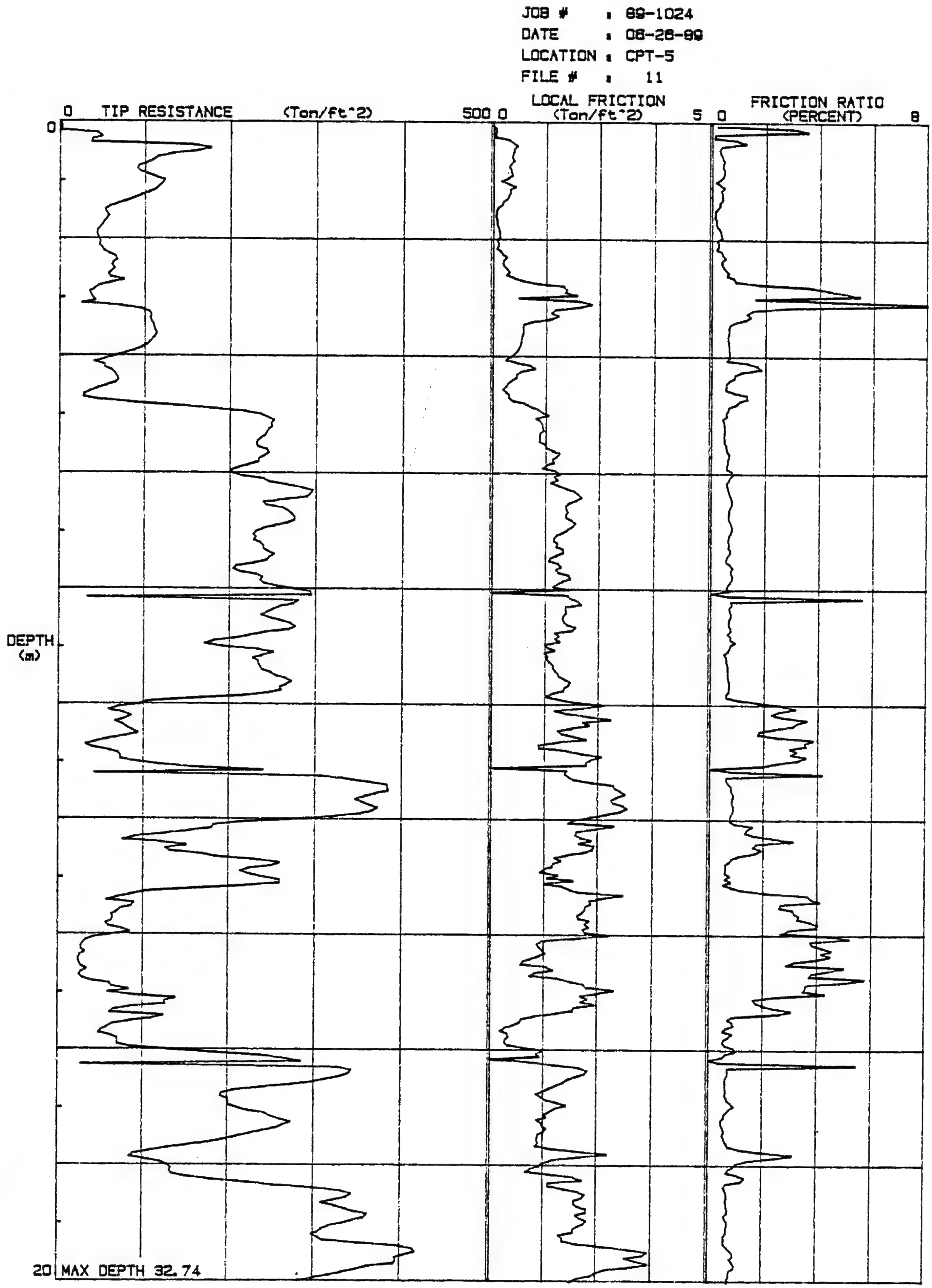


JOB # : 89-1024
DATE : 08-24-89
LOCATION : CPT-4
FILE # : 7



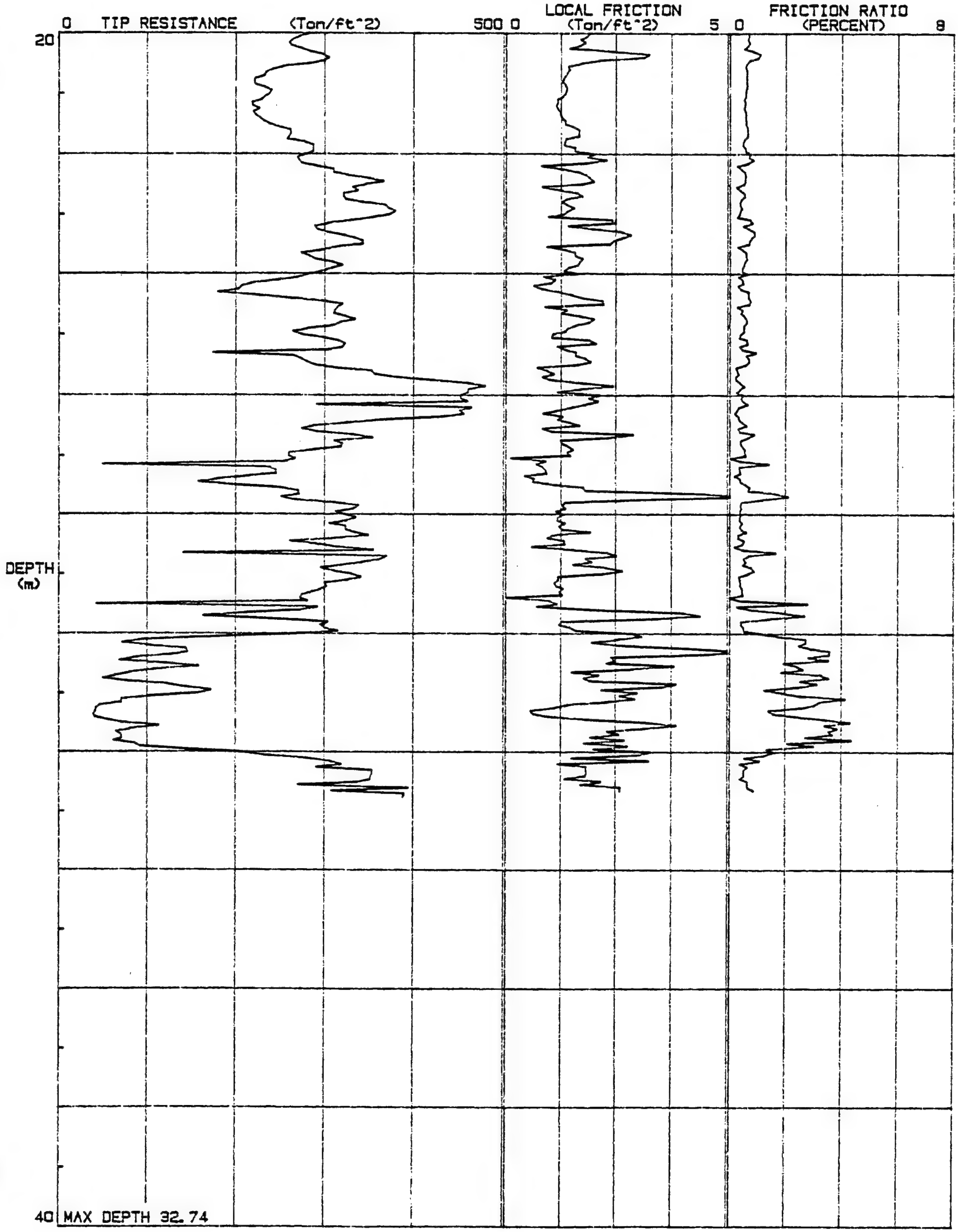
DATE : 08-24-89
LOCATION : CPT-4
FILE # : 7



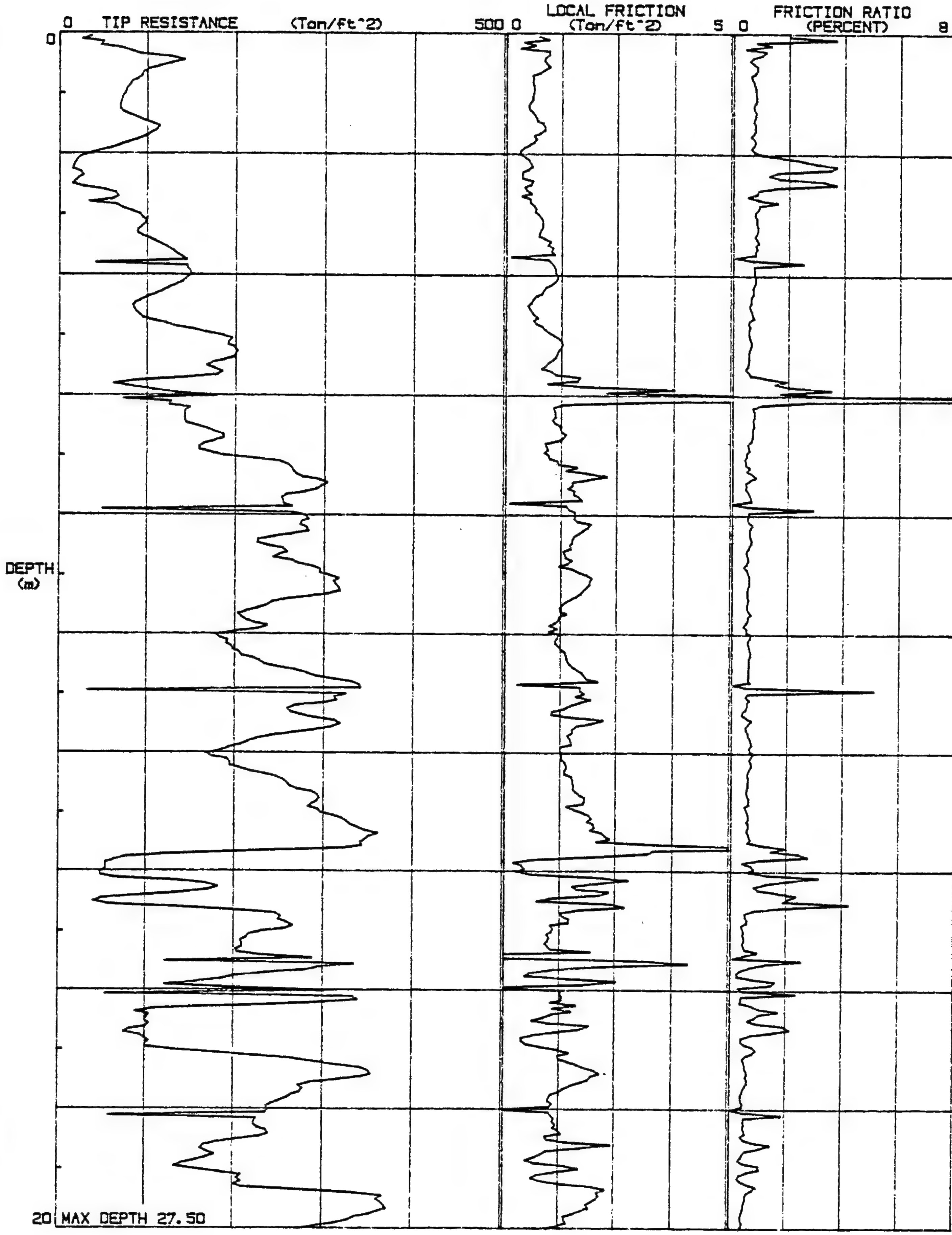


JOB # : 89-1024
DATE : 08-28-89
LOCATION : CPT-5
FILE # : 11
0 TIP RESISTANCE (Ton/ft^2) 500
0 LOCAL FRICTION (Ton/ft^2) 5
0 FRICTION RATIO (PERCENT) 8
DEPTH (m)
0
20
MAX DEPTH 32.74

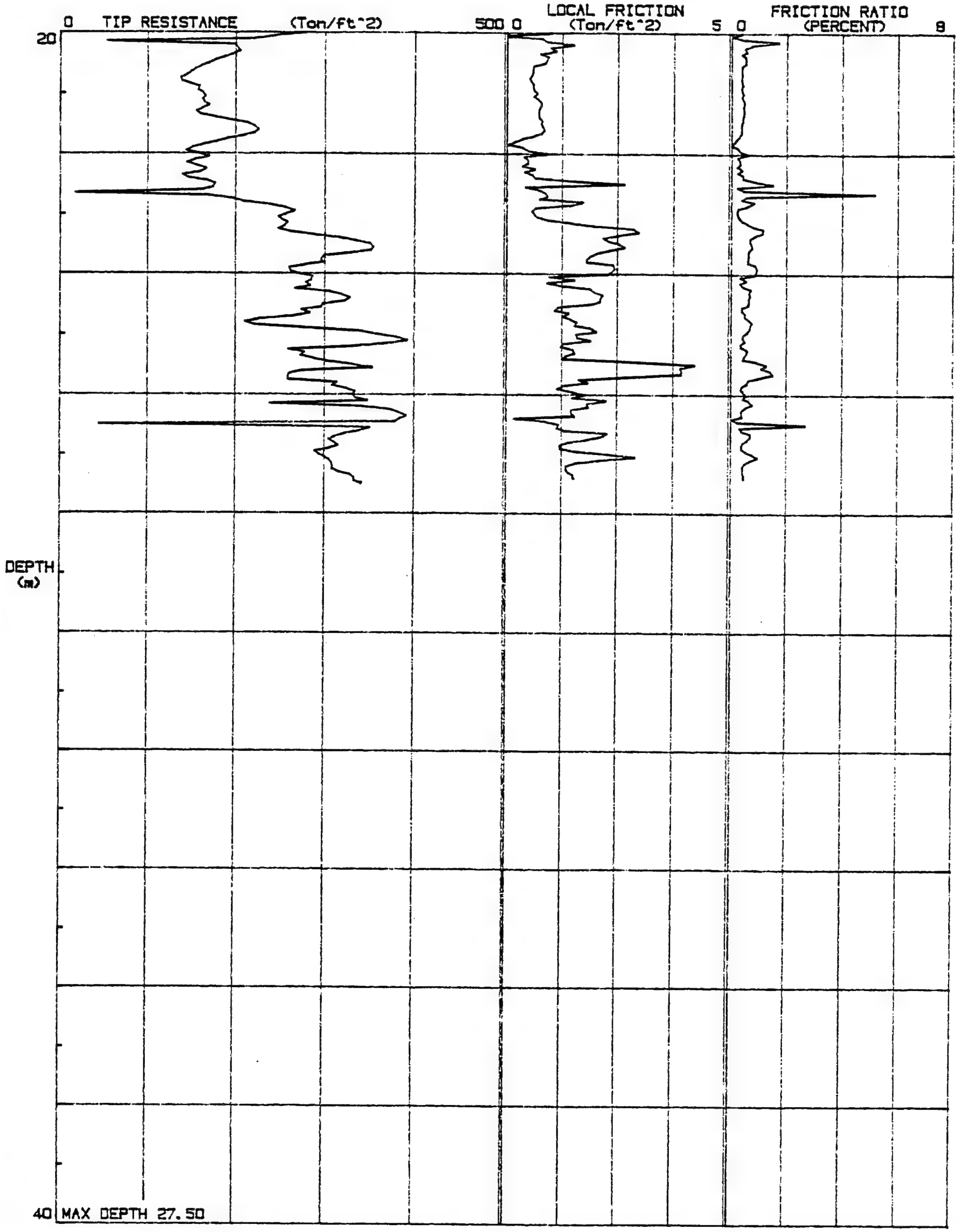
JOB # : 89-1024
DATE : 06-26-89
LOCATION : CPT-5
FILE # : 11



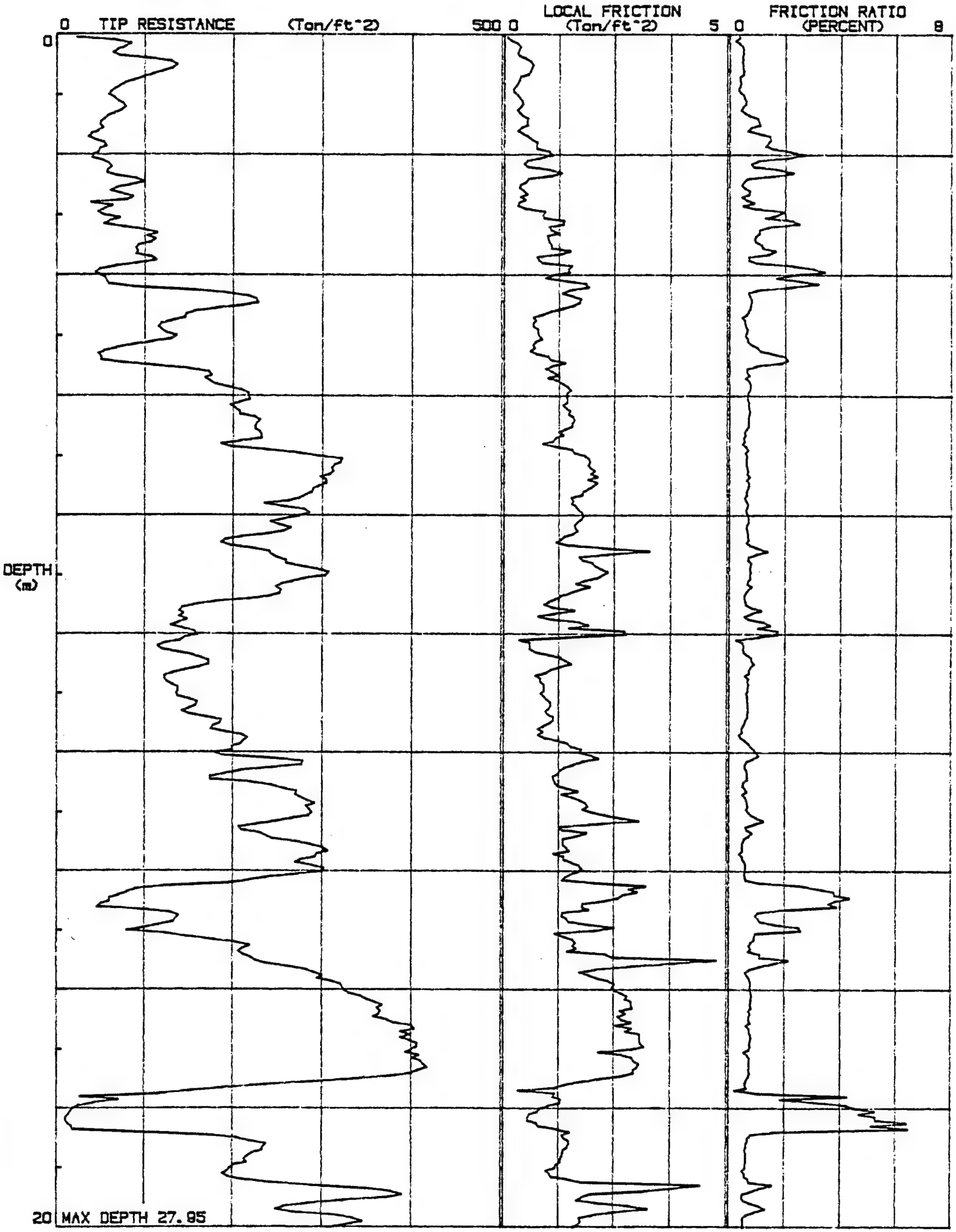
JOB # : 89-1024
DATE : 08-28-89
LOCATION : CPT-8
FILE # : 12



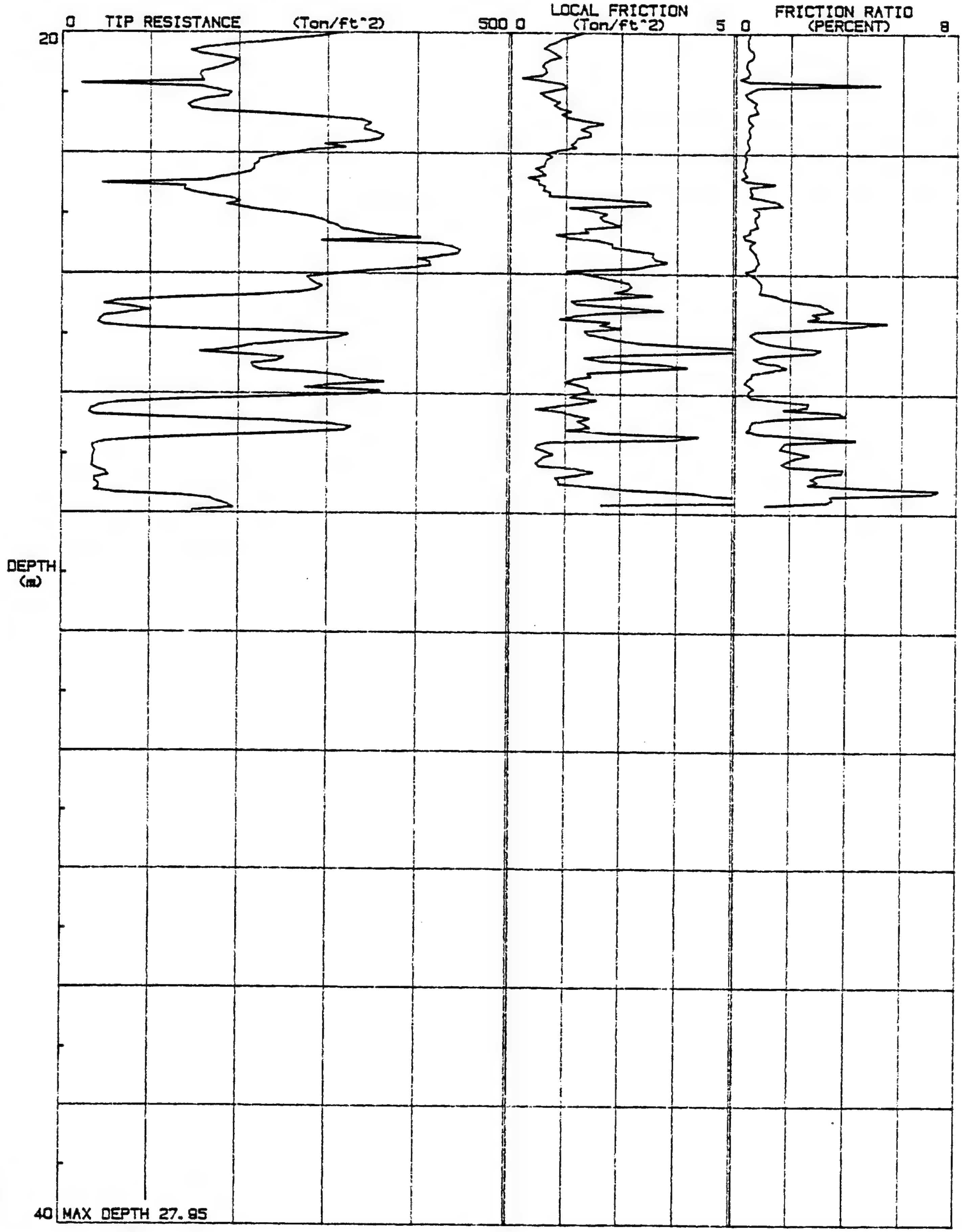
DATE : 06-28-89
LOCATION : CPT-8
FILE # : 12



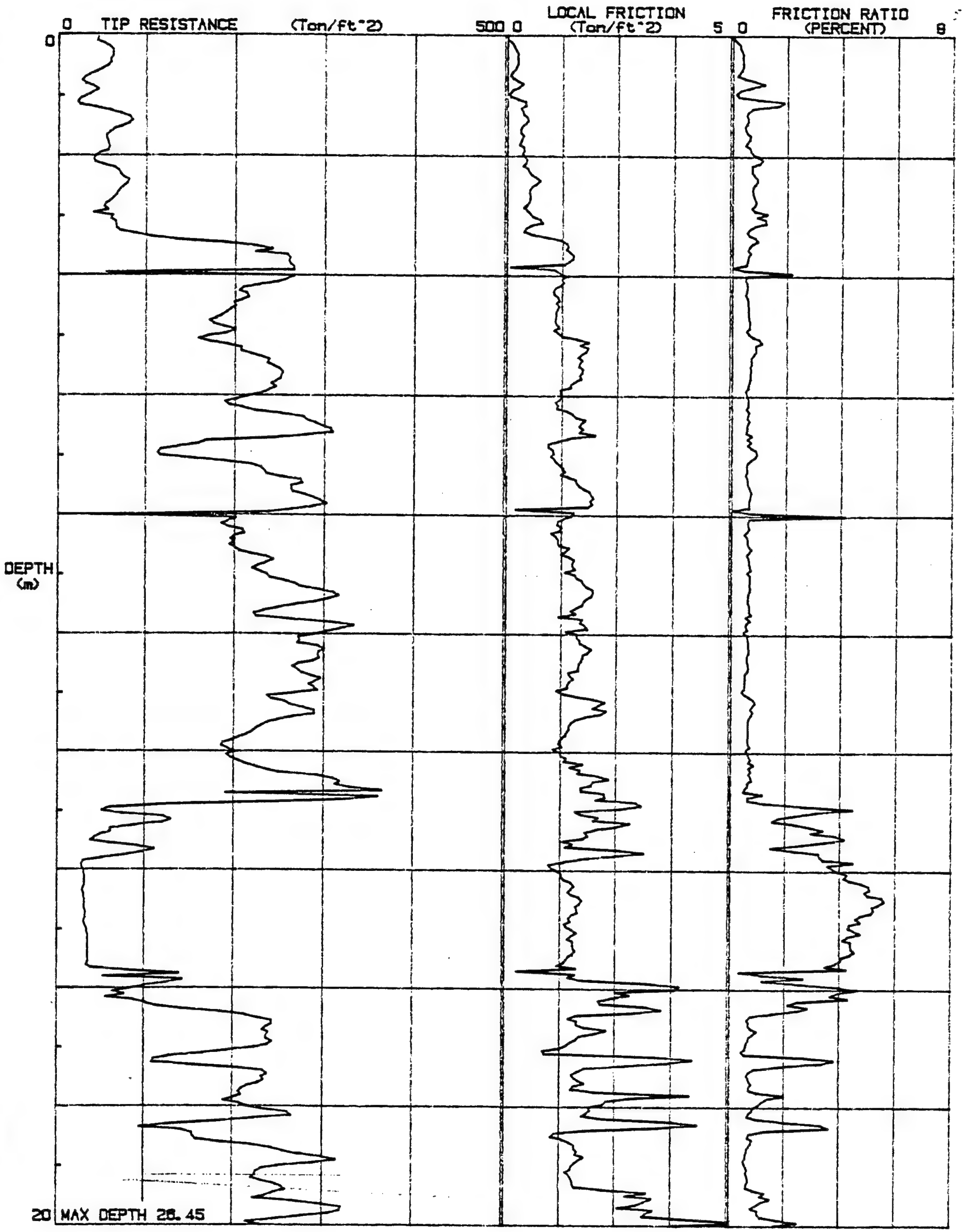
JOB # : 89-1024
DATE : 08-27-89
LOCATION : CPT-7
FILE # : 13



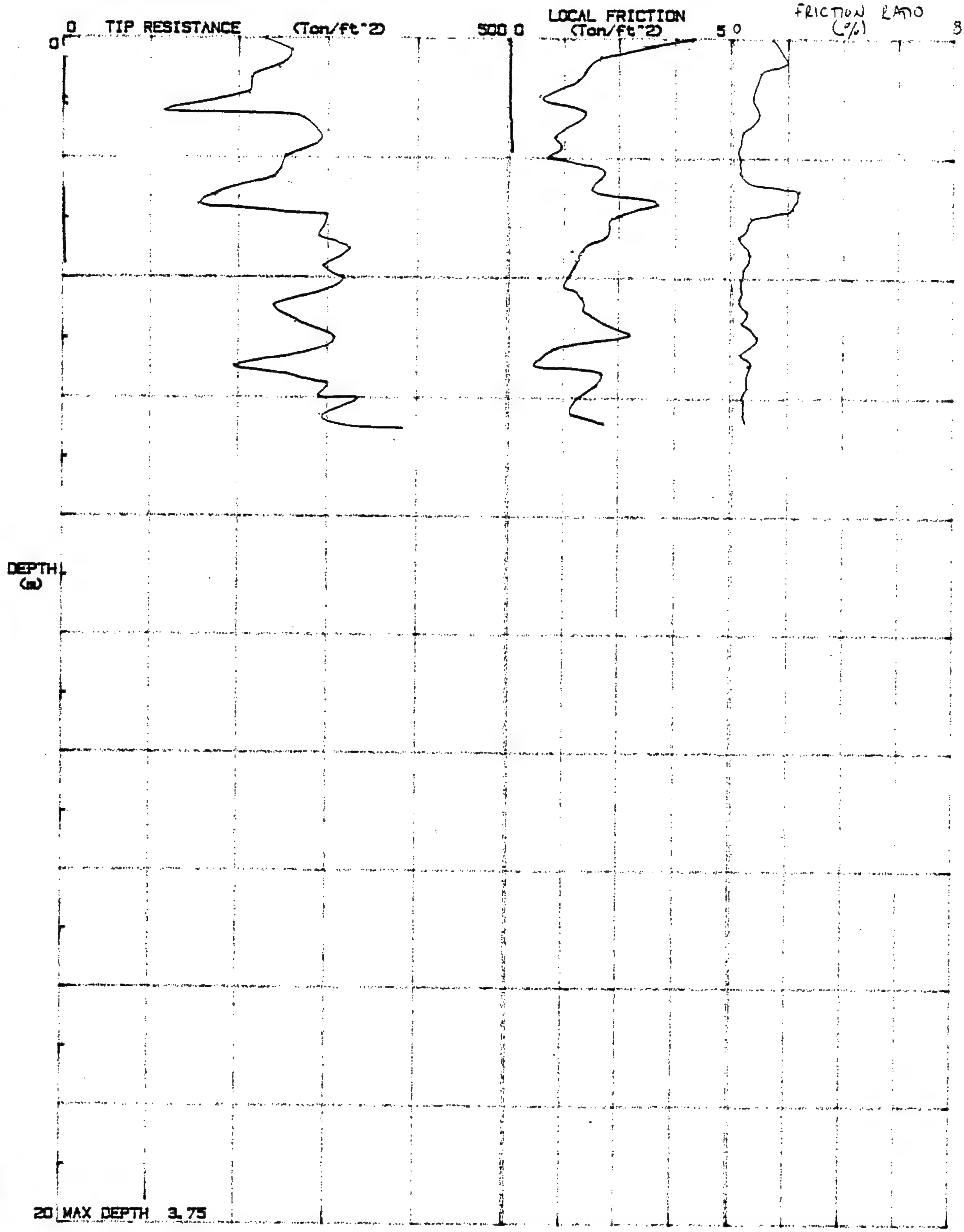
DATE : 08-27-89
LOCATION : CPT-7
FILE # : 13



JOB # : 89-1024
DATE : 08-27-89
LOCATION : CPT-8
FILE # : 14



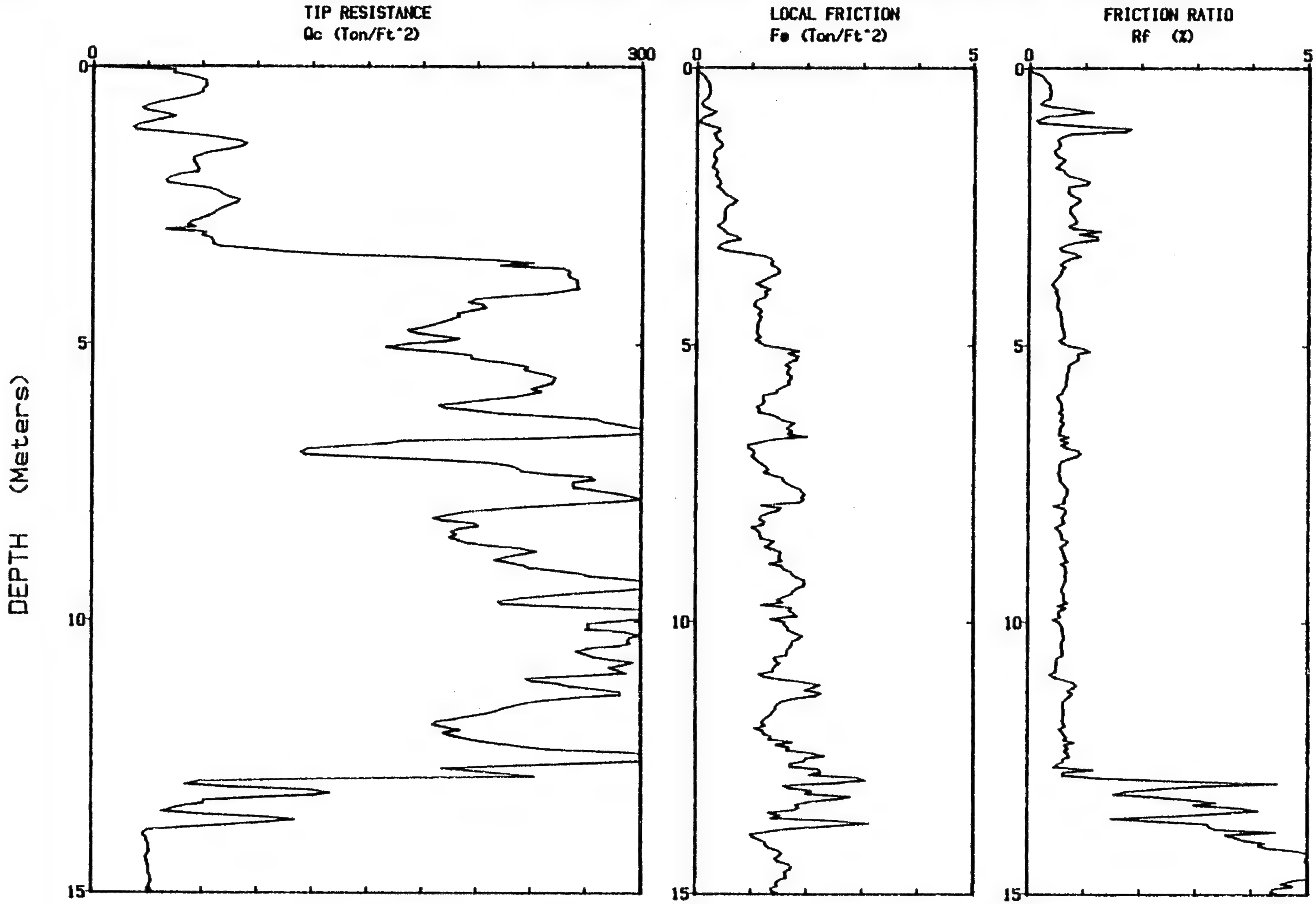
DATE : ~~08-22-89~~ 06-27-89
LOCATION : ~~CALIB~~ CPT-8
FILE # : ~~2~~ 14



RAILYARD DBCP STUDY

Contractor: TERRA TECH. Test Date : 06-27-88 Page No: 1 / 2

Location: CPT-8 Elevation: UNKNOWN TERRA Job No.: 89-1024

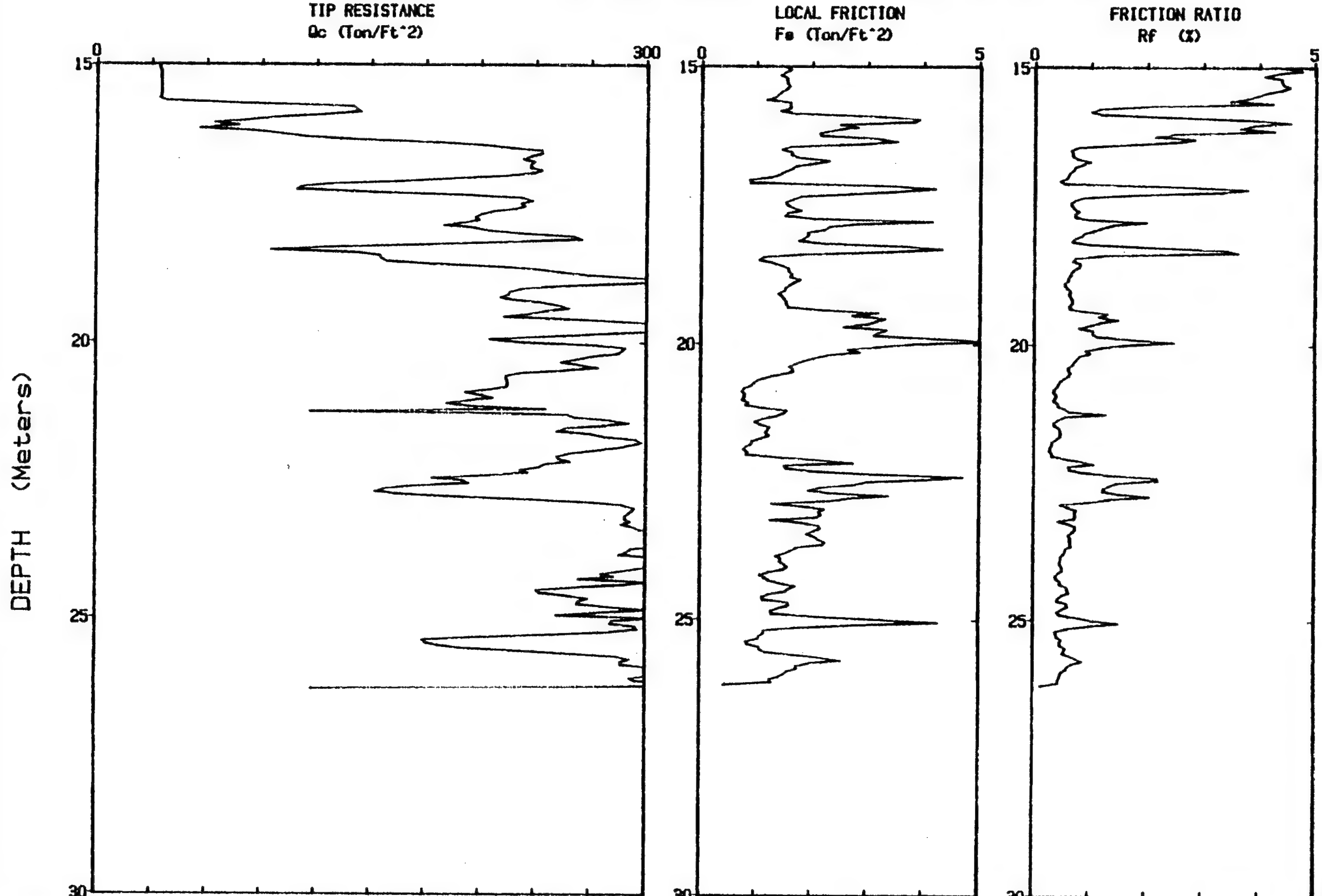


Depth Increment : .05 m

Max Depth : 26.3 m

RAILYARD DBCP STUDY

Contractor: TERRA TECH. | Test Date : 06-27-89 | Page No: 2 / 2
Location: CPT-8 | Elevation: UNKNOWN | TERRA Job No.: 89-1024



Depth Increment : .05 m

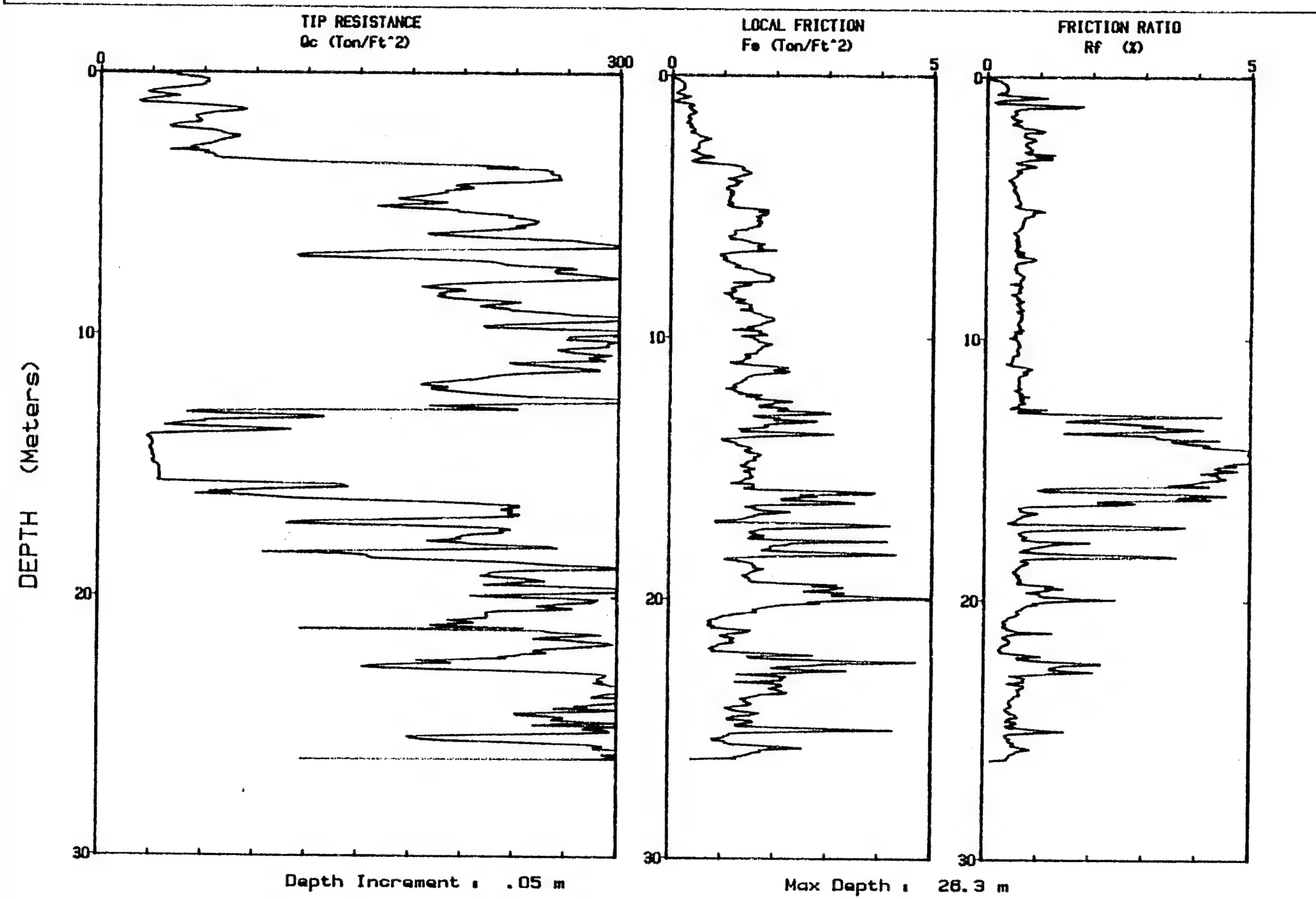
Max Depth : 26.3 m

RAILYARD DBCP STUDY

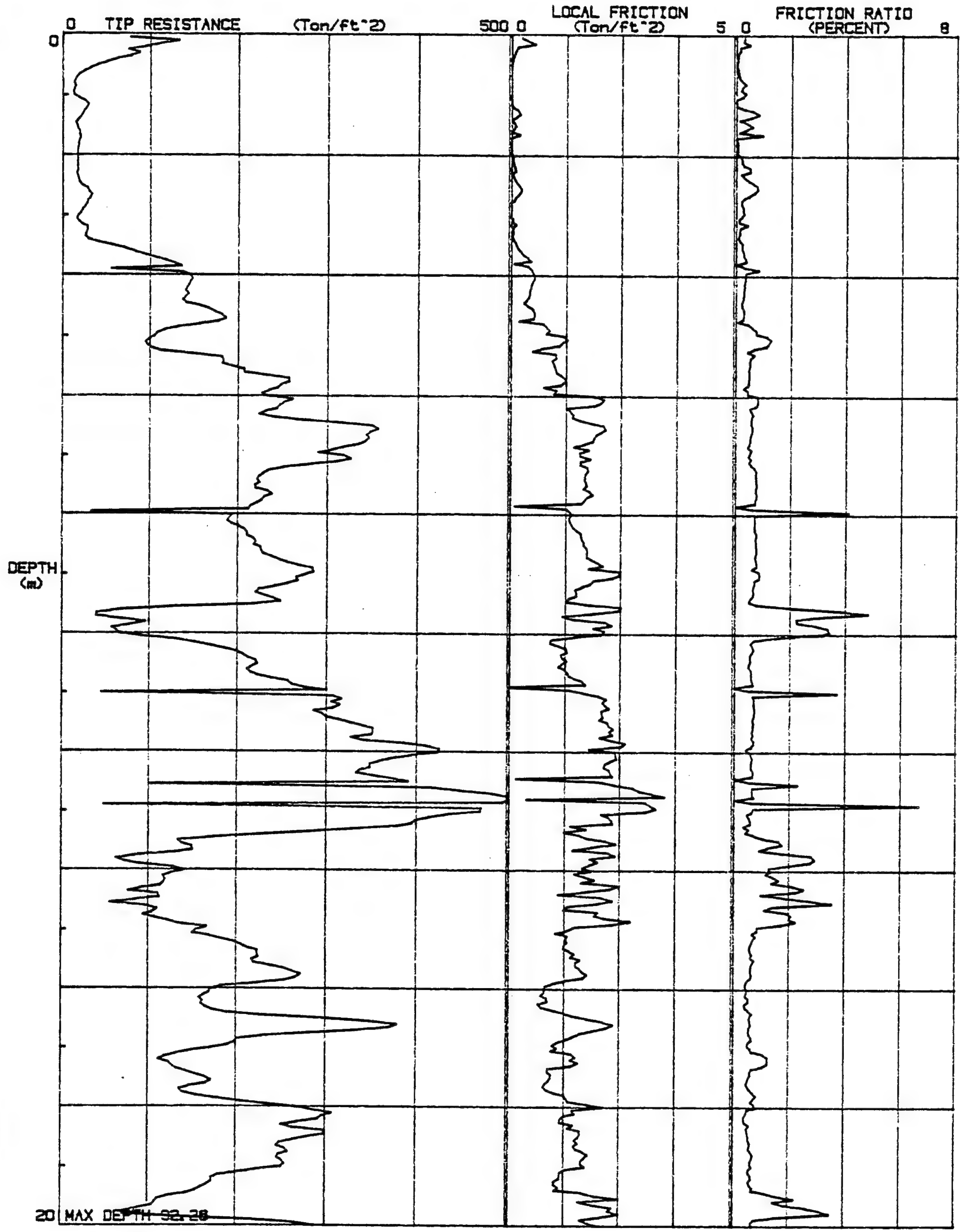
Contractor: TERRA TECH.
Location: CPT-8

Test Date : 08-27-89
Elevation: UNKNOWN

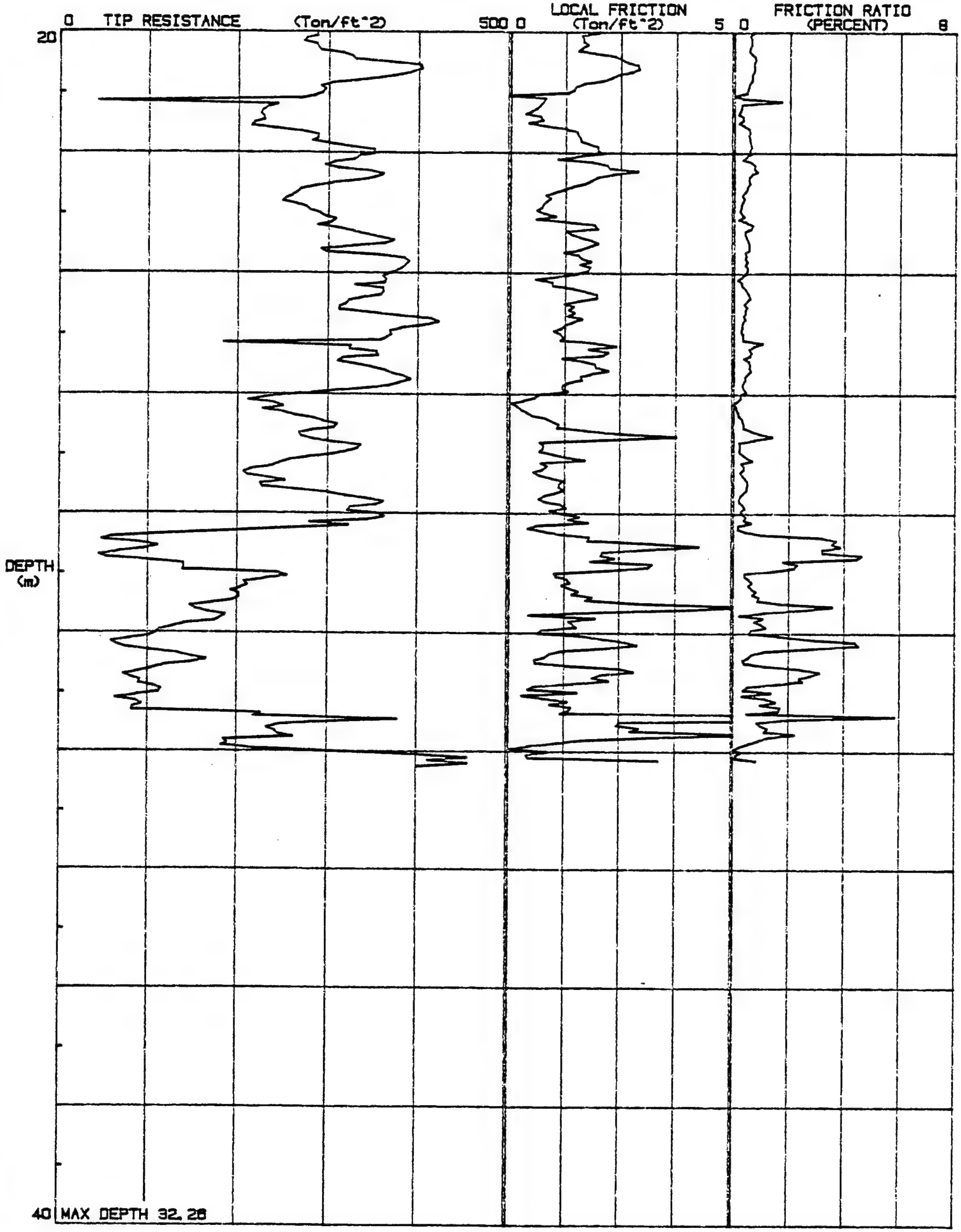
Page No: 1 / 1
TERRA Job No.: 89-1024



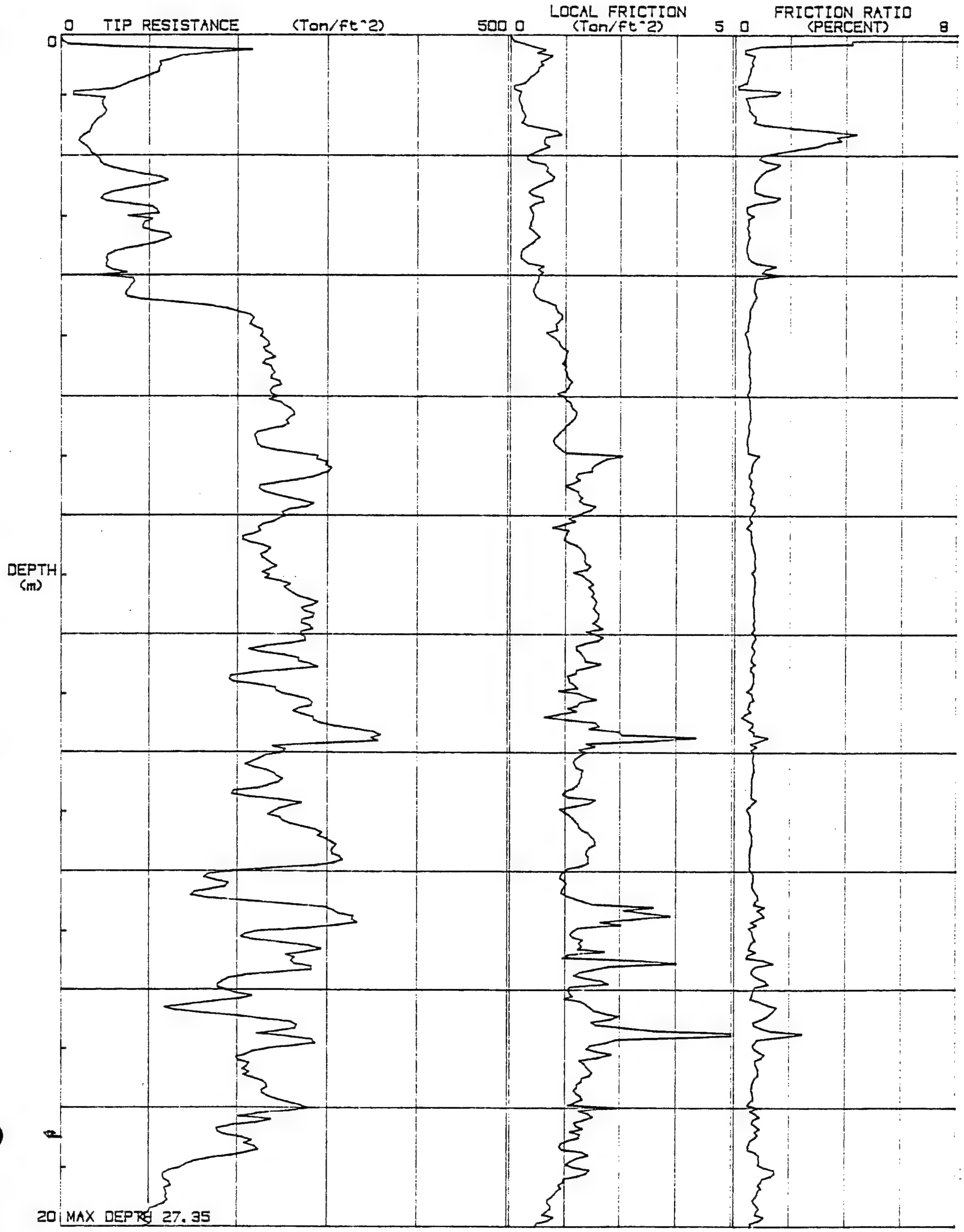
JOB # : 88-1024
DATE : 08-27-88
LOCATION : CPT-9
FILE # : 15



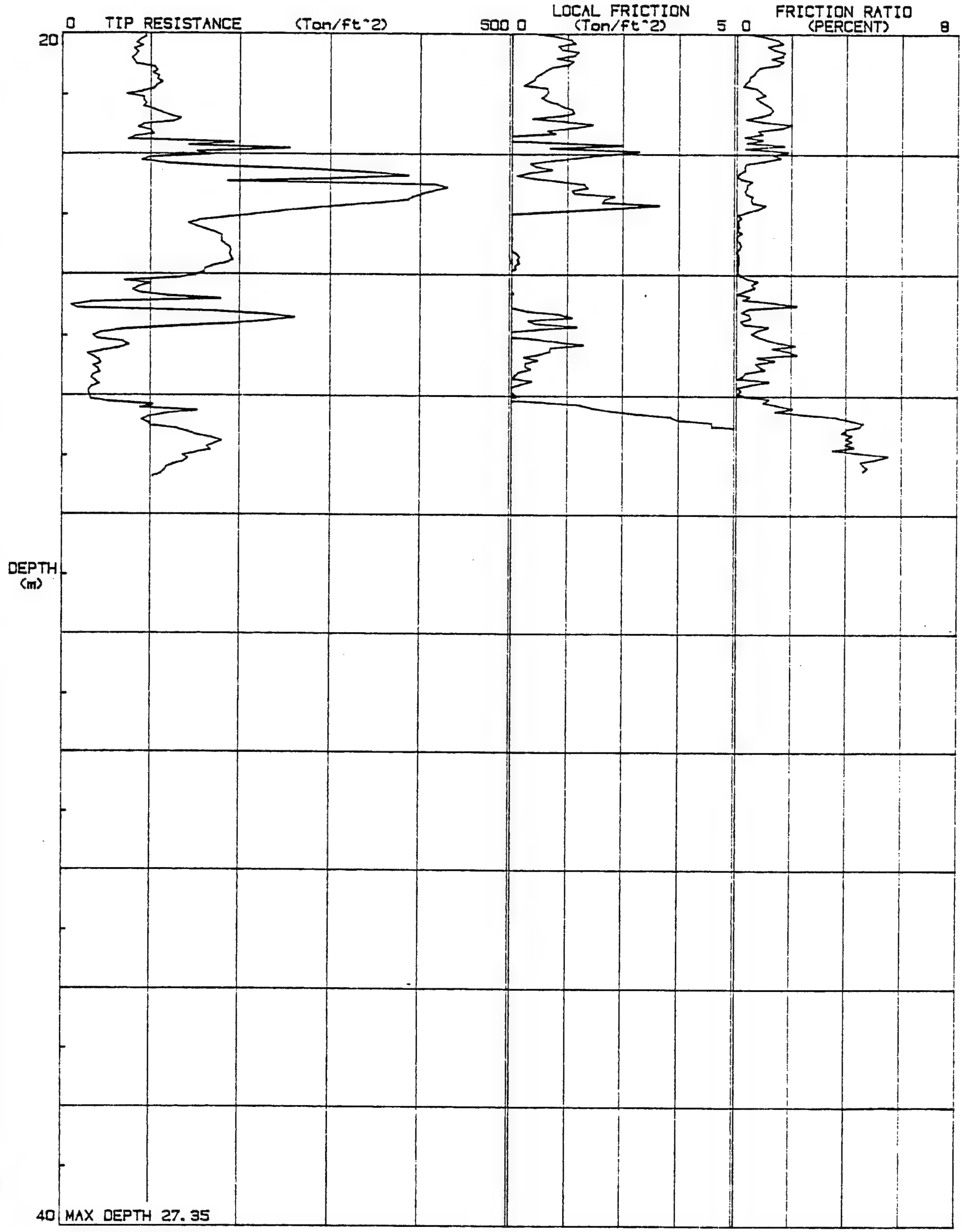
DATE : 08-27-89
LOCATION : CPT-9
FILE # : 15



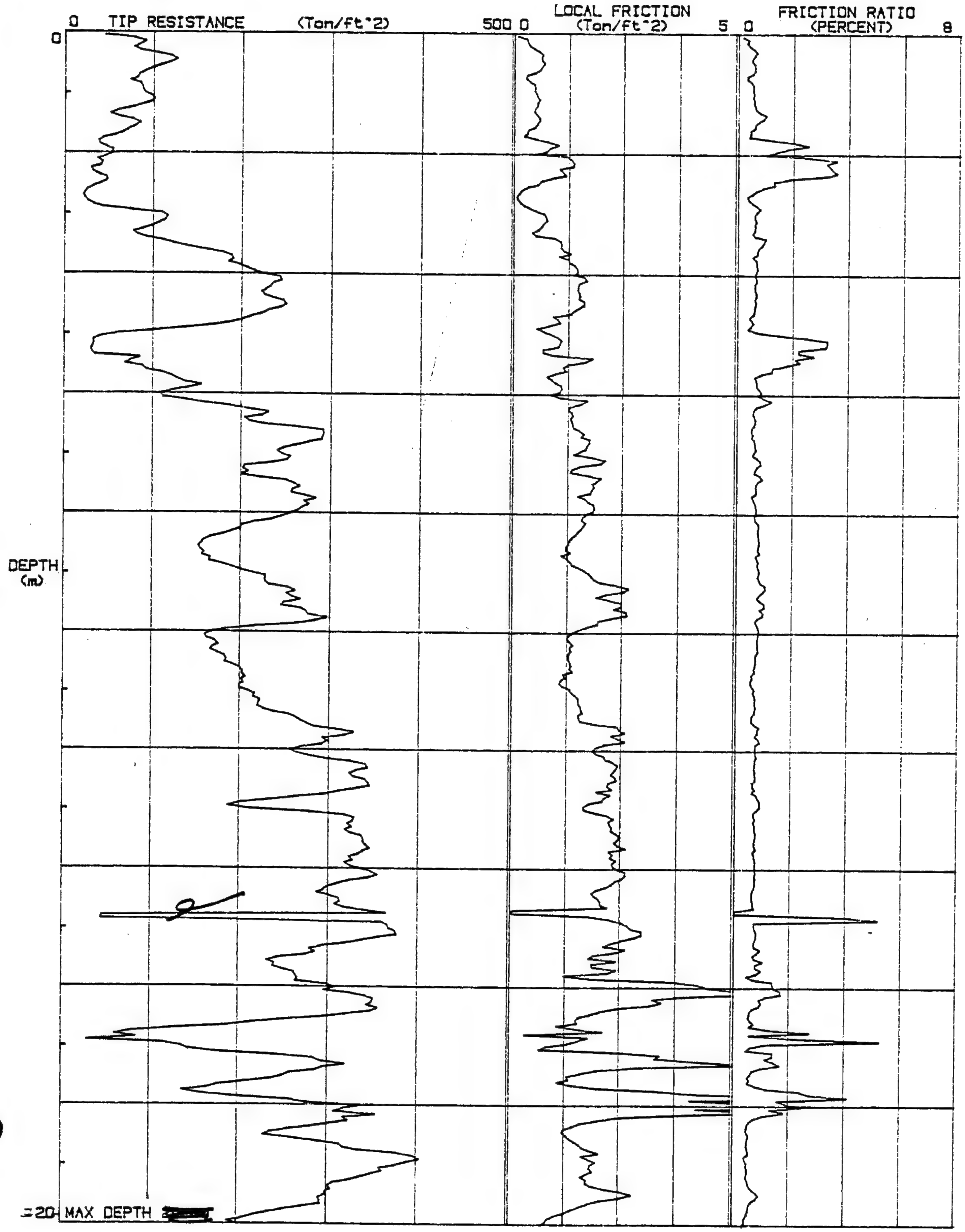
JOB # : 89-1024
DATE : 07-04-89
LOCATION : CPT-10
FILE # : 16



DATE : 07-04-89
LOCATION : CPT-10
FILE # : 16

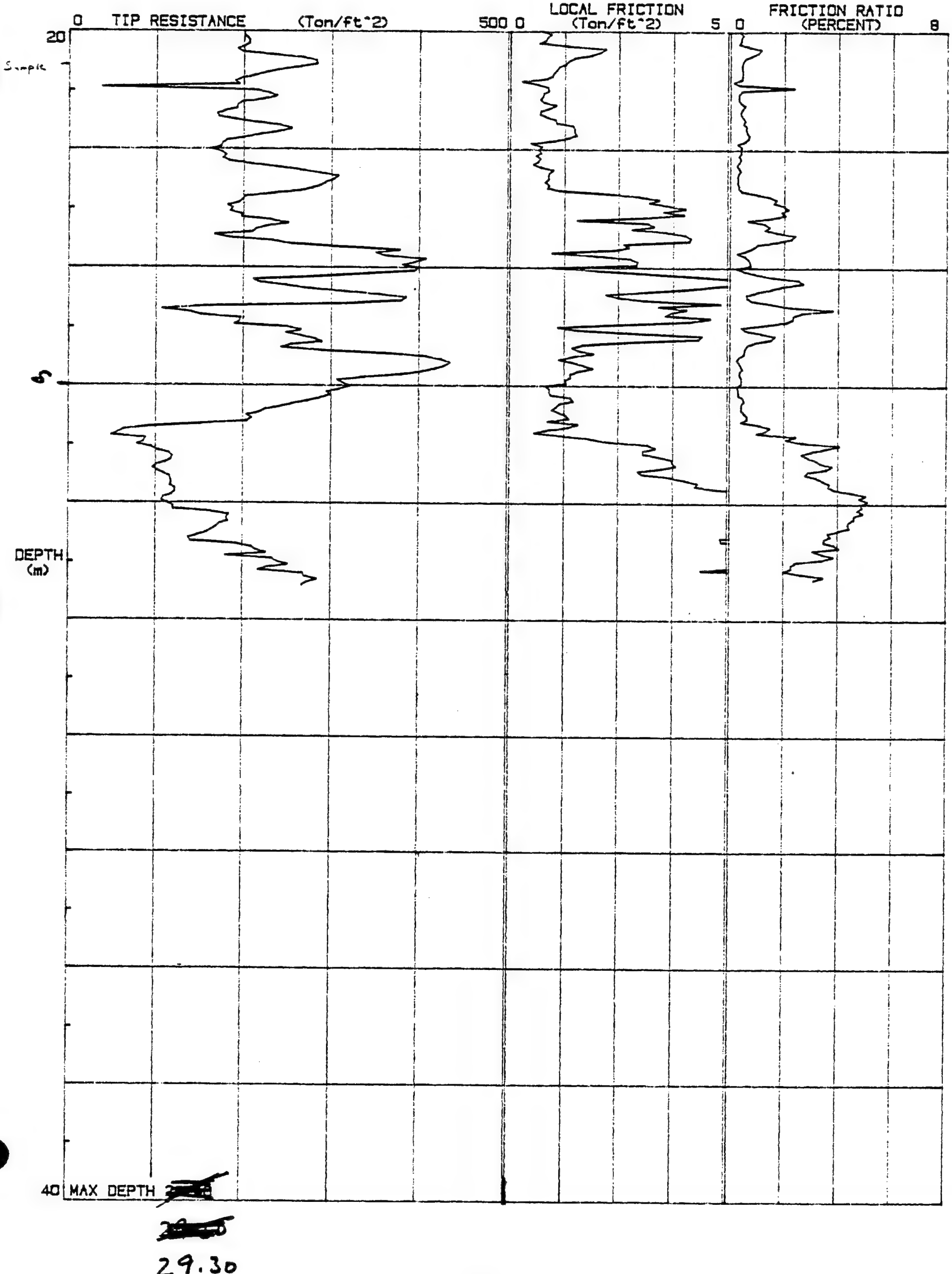


JOB # : 89-1024
DATE : 07-19-89
LOCATION : CPT-11
FILE # : 17

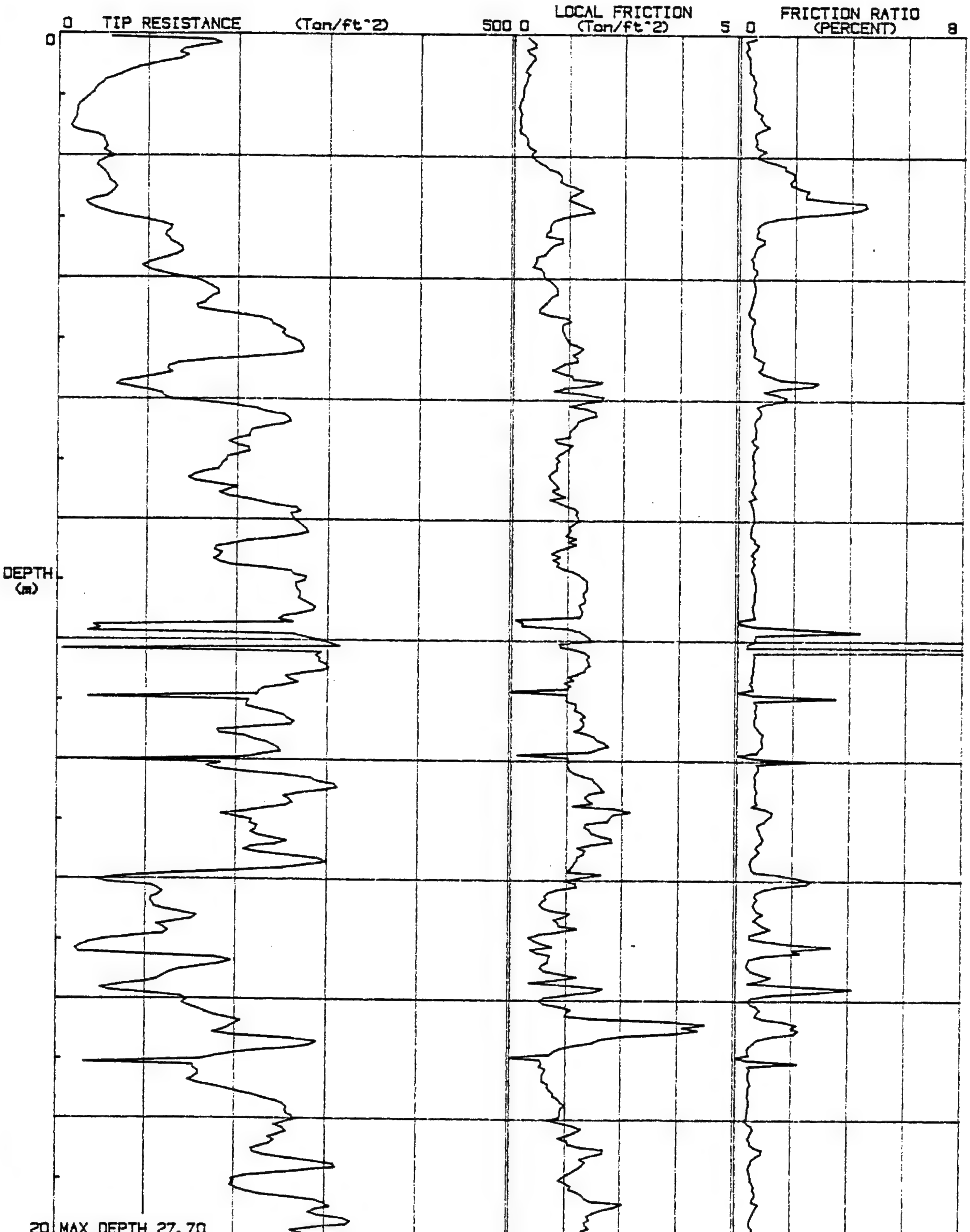


29.30

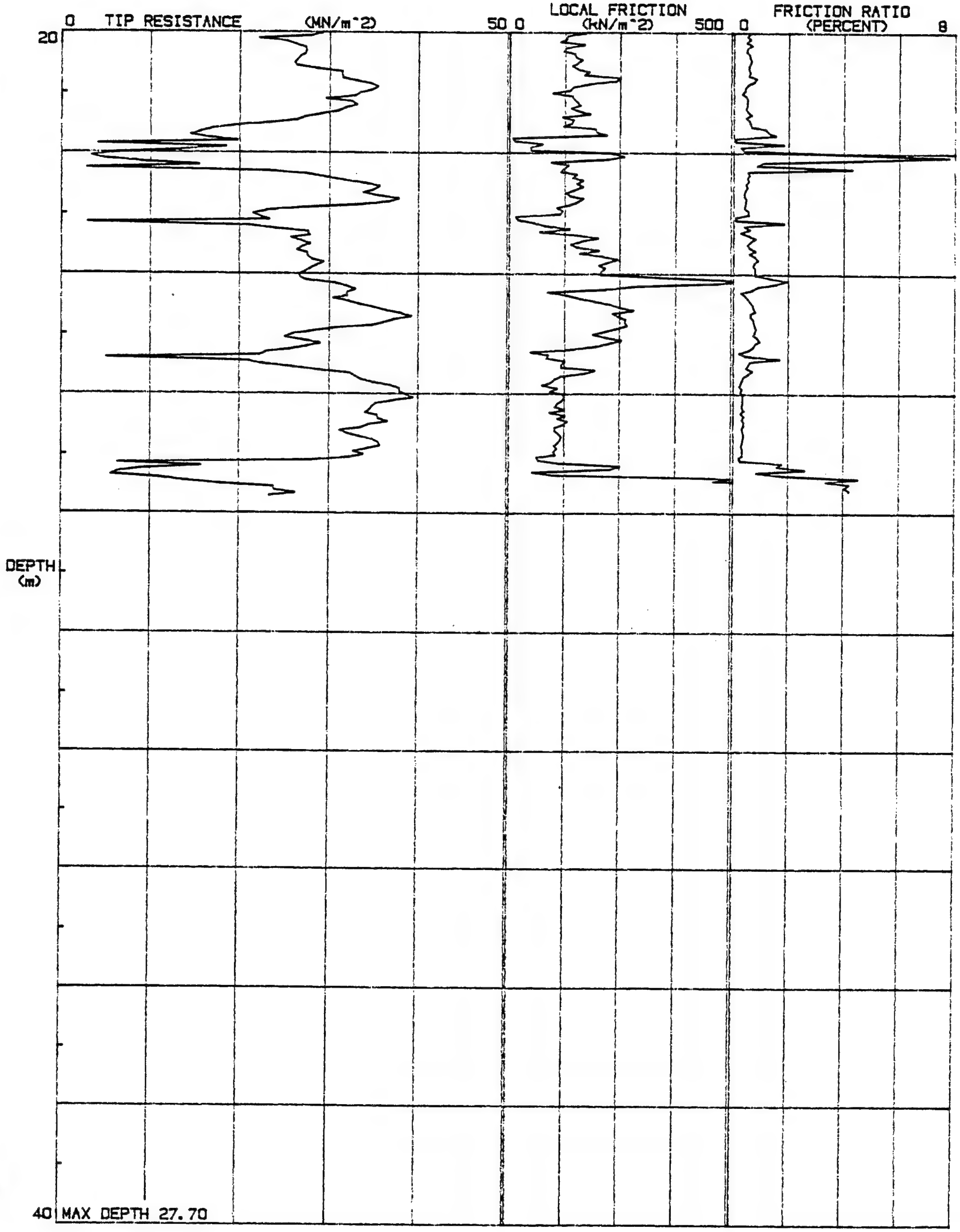
JOB # : 89-1024
DATE : 07-19-89
LOCATION : CPT-11
FILE # : 17



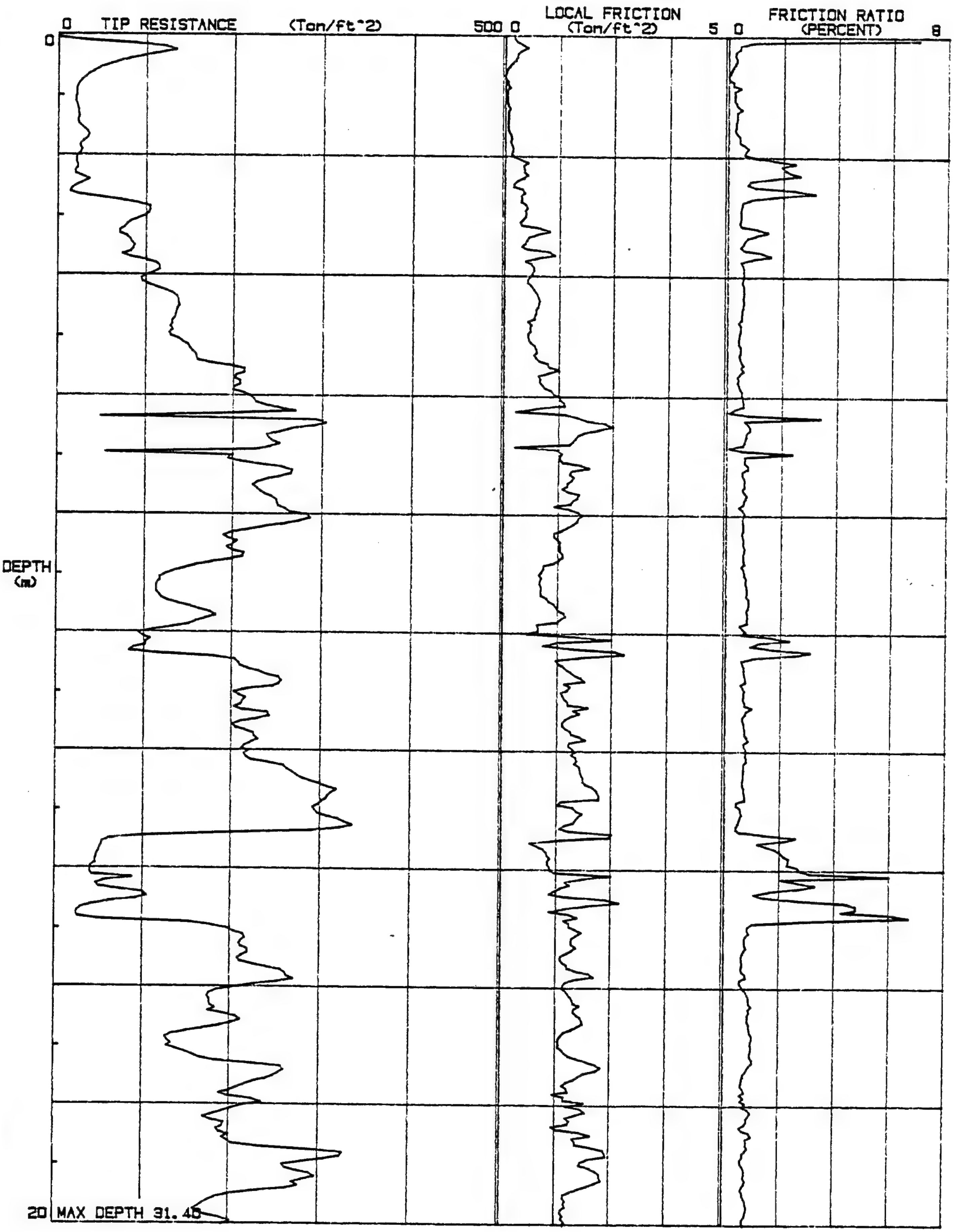
JOB # : 89-1024
DATE : 07-20-89
LOCATION : CPT-12
FILE # : 19



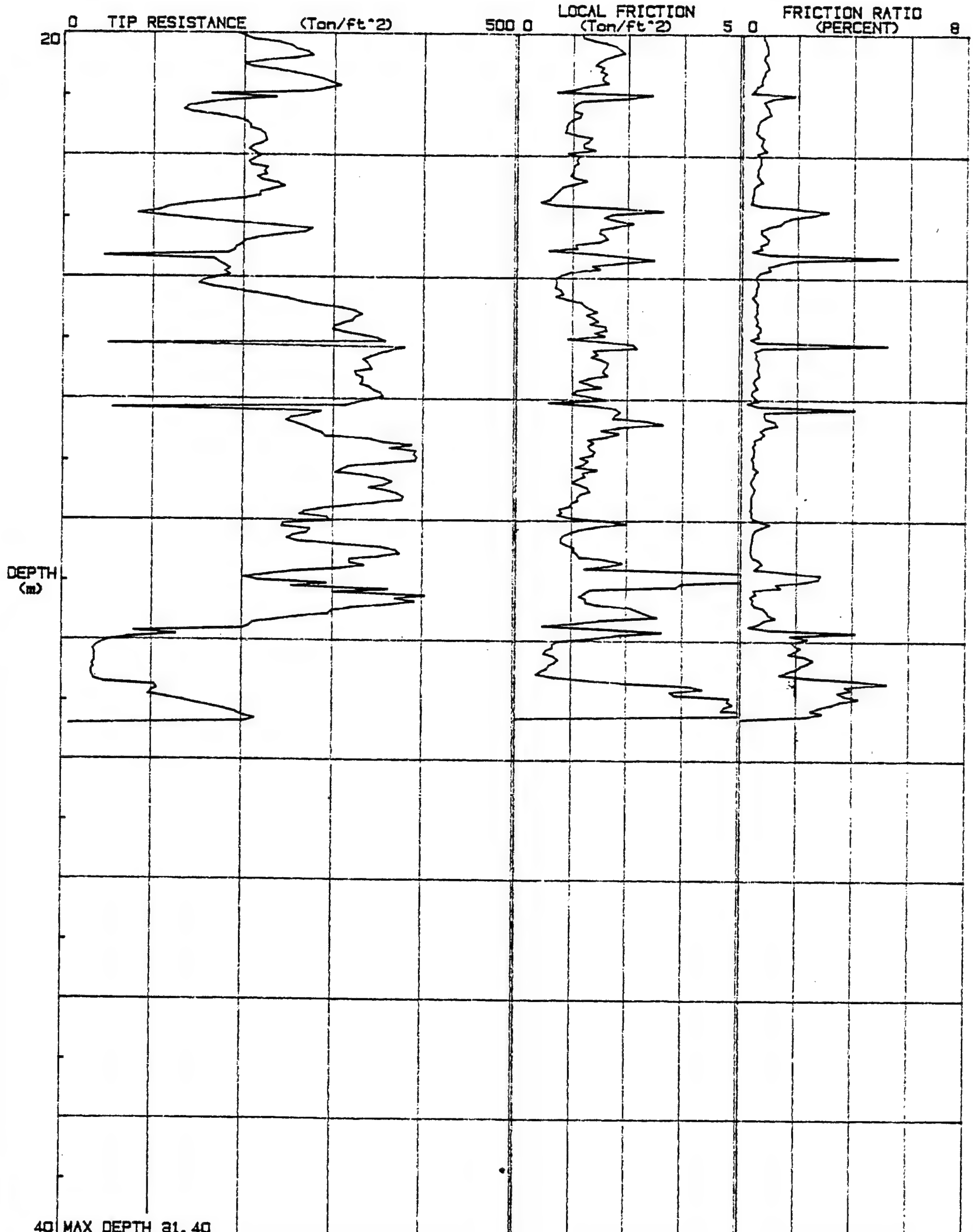
DATE : 07-20-89
LOCATION : CPT-12
FILE # : 19



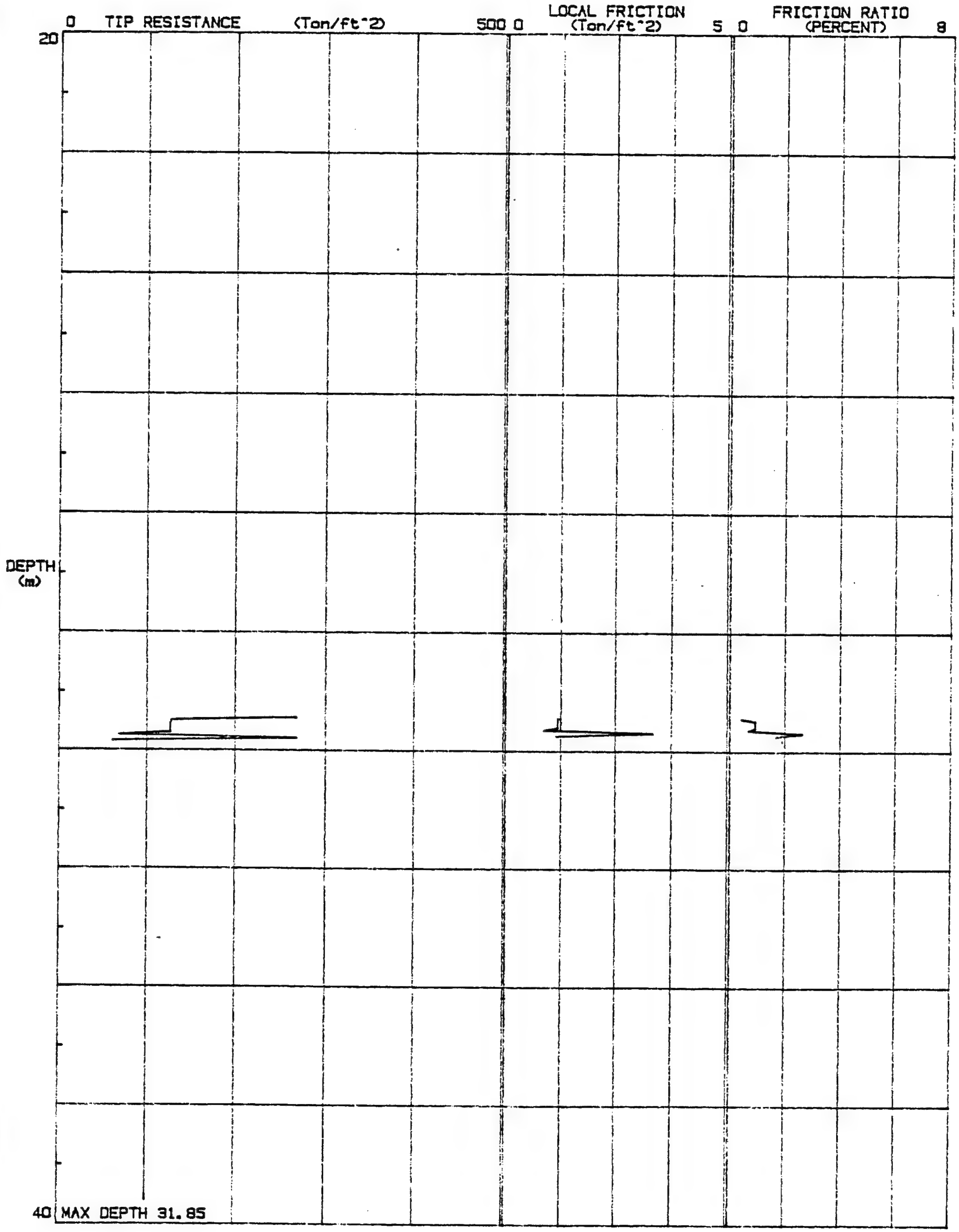
JOB # : 89-1024
DATE : 07-21-89
LOCATION : CPT-13
FILE # : 20



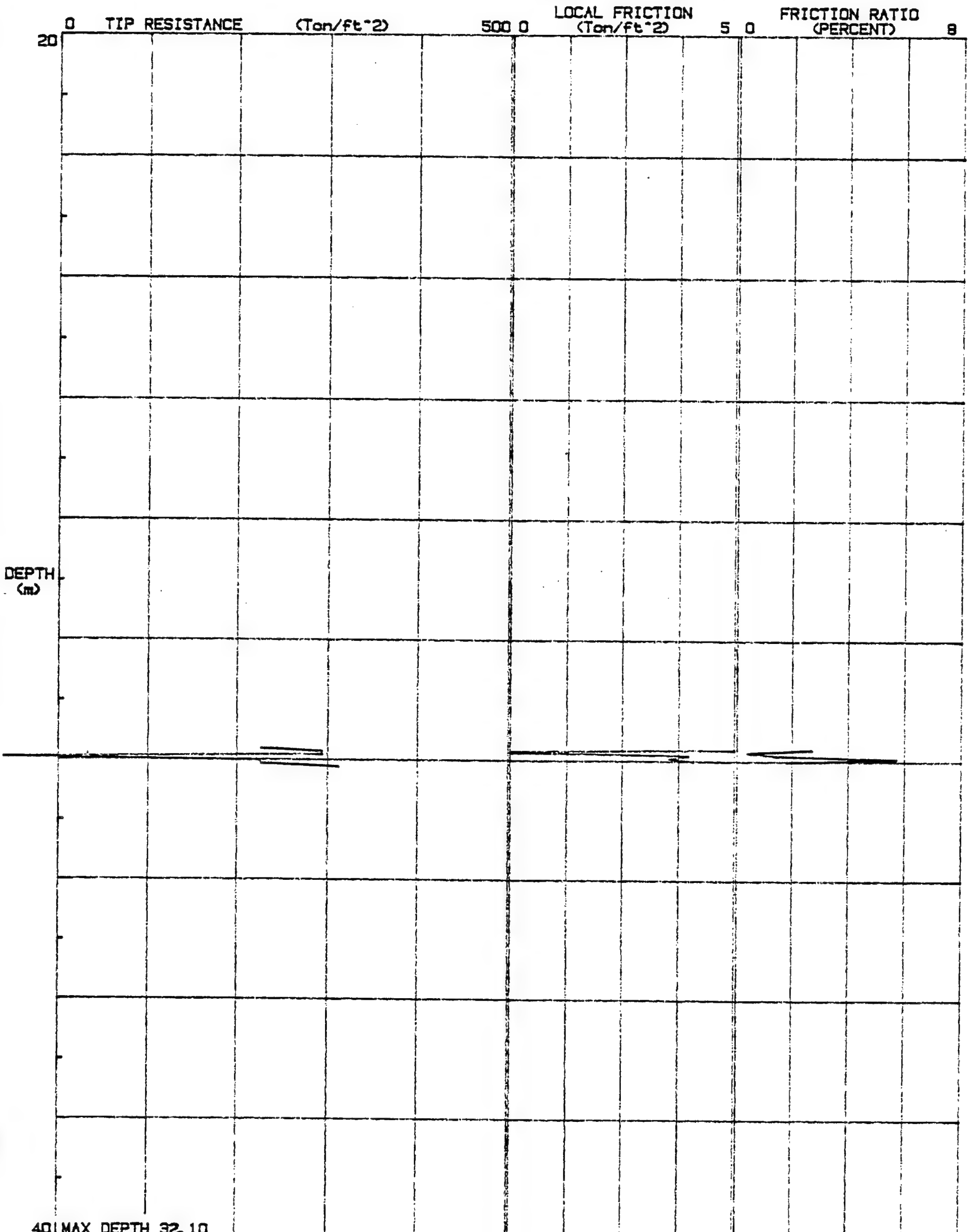
DATE : 07-21-89
LOCATION : CPT-13
FILE # : 20



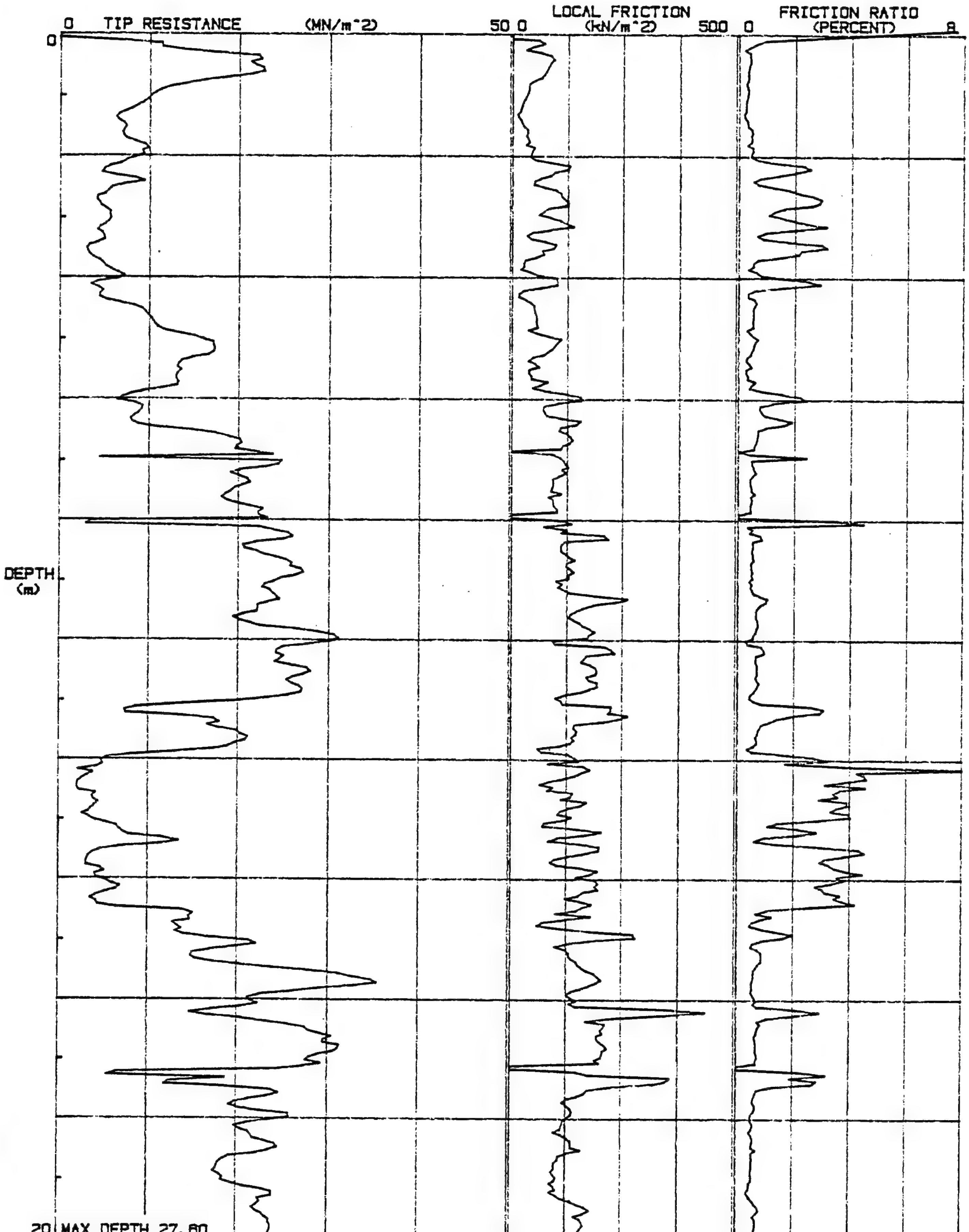
JOB # : 89-1024
DATE : 07-21-89
LOCATION : CPT-13A
FILE # : 21



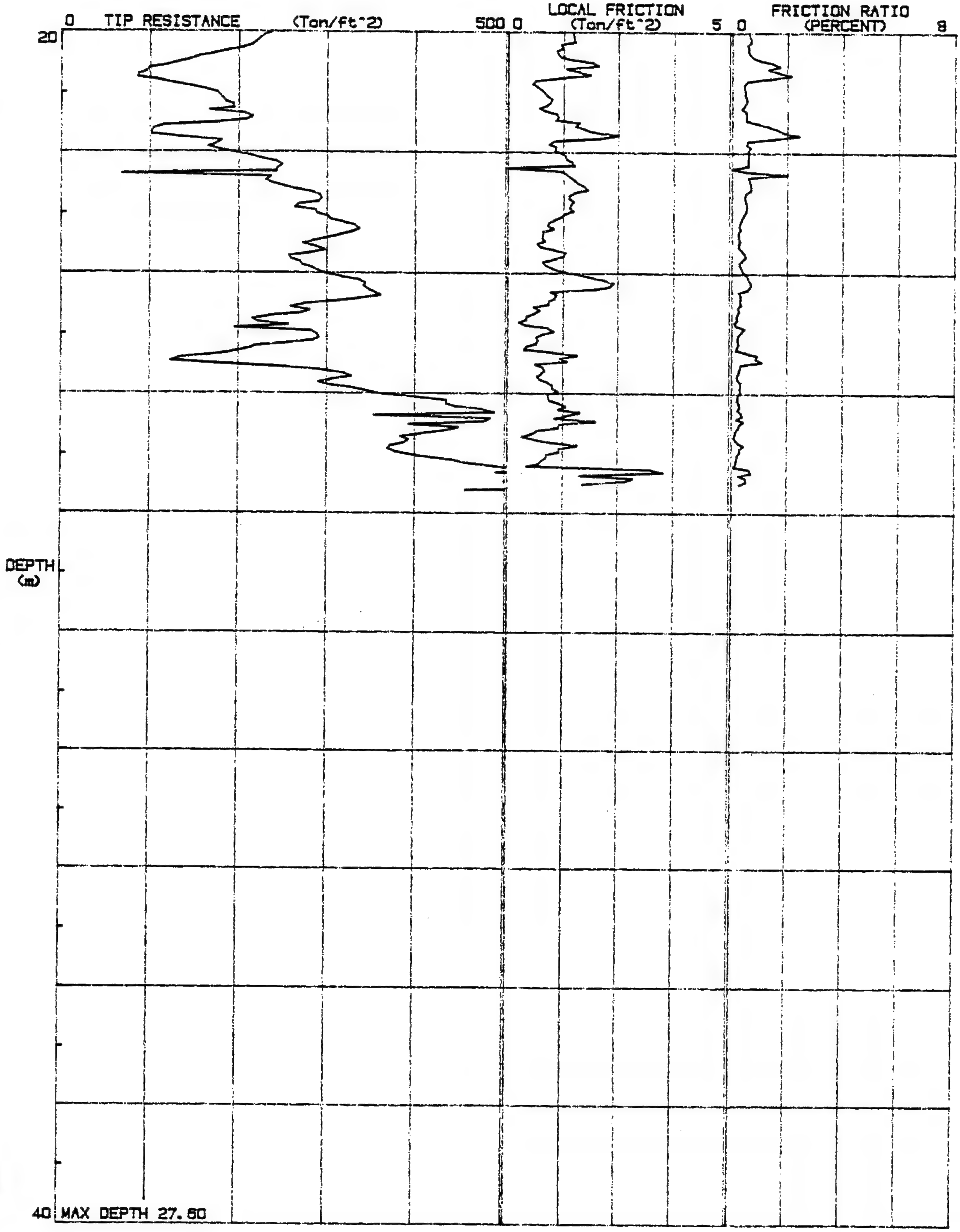
JOB # : 89-1024
DATE : 07-21-89
LOCATION : CPT-138
FILE # : 22



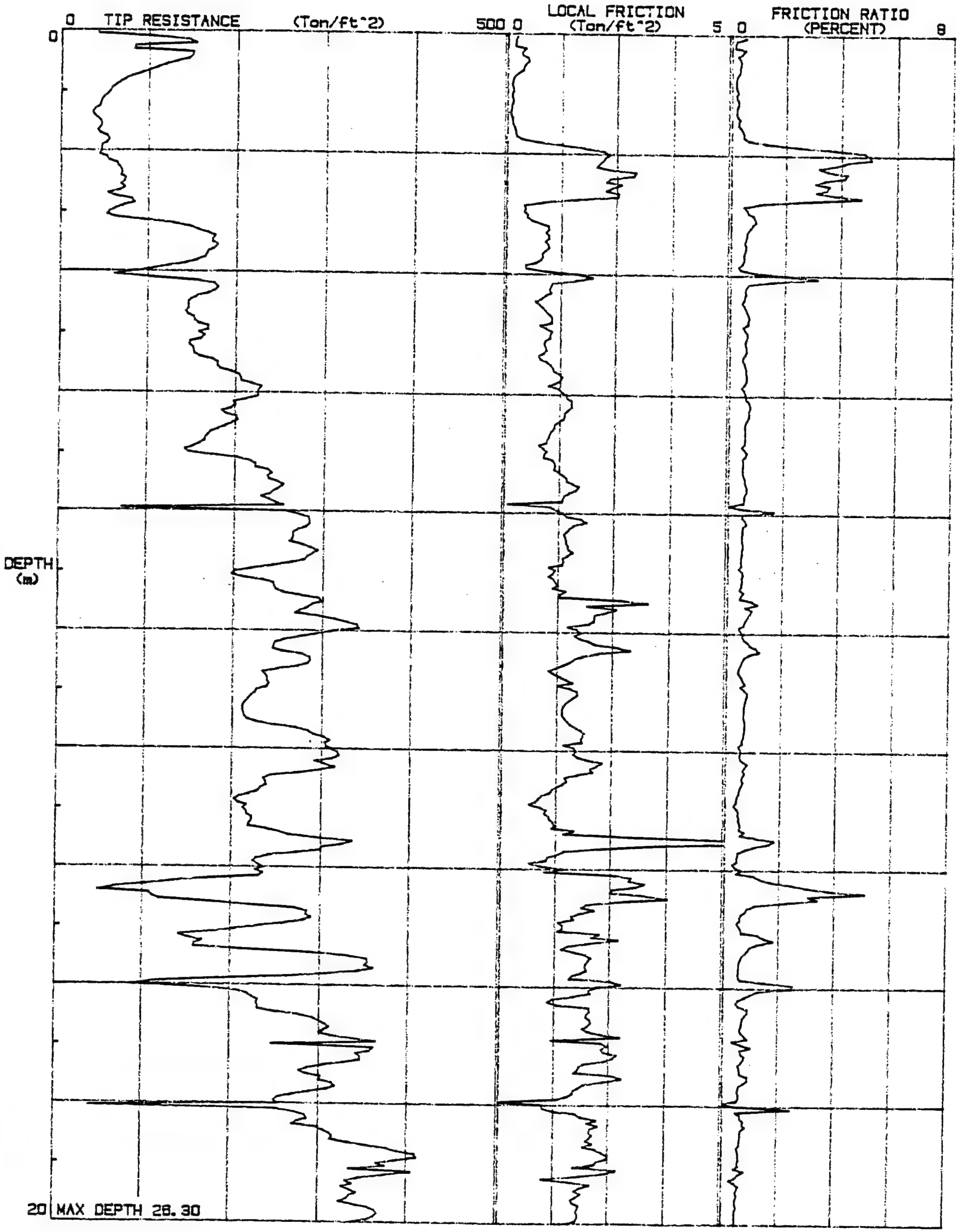
JOB # : 89-1024
DATE : 07-22-89
LOCATION : CPT-14
FILE # : 23



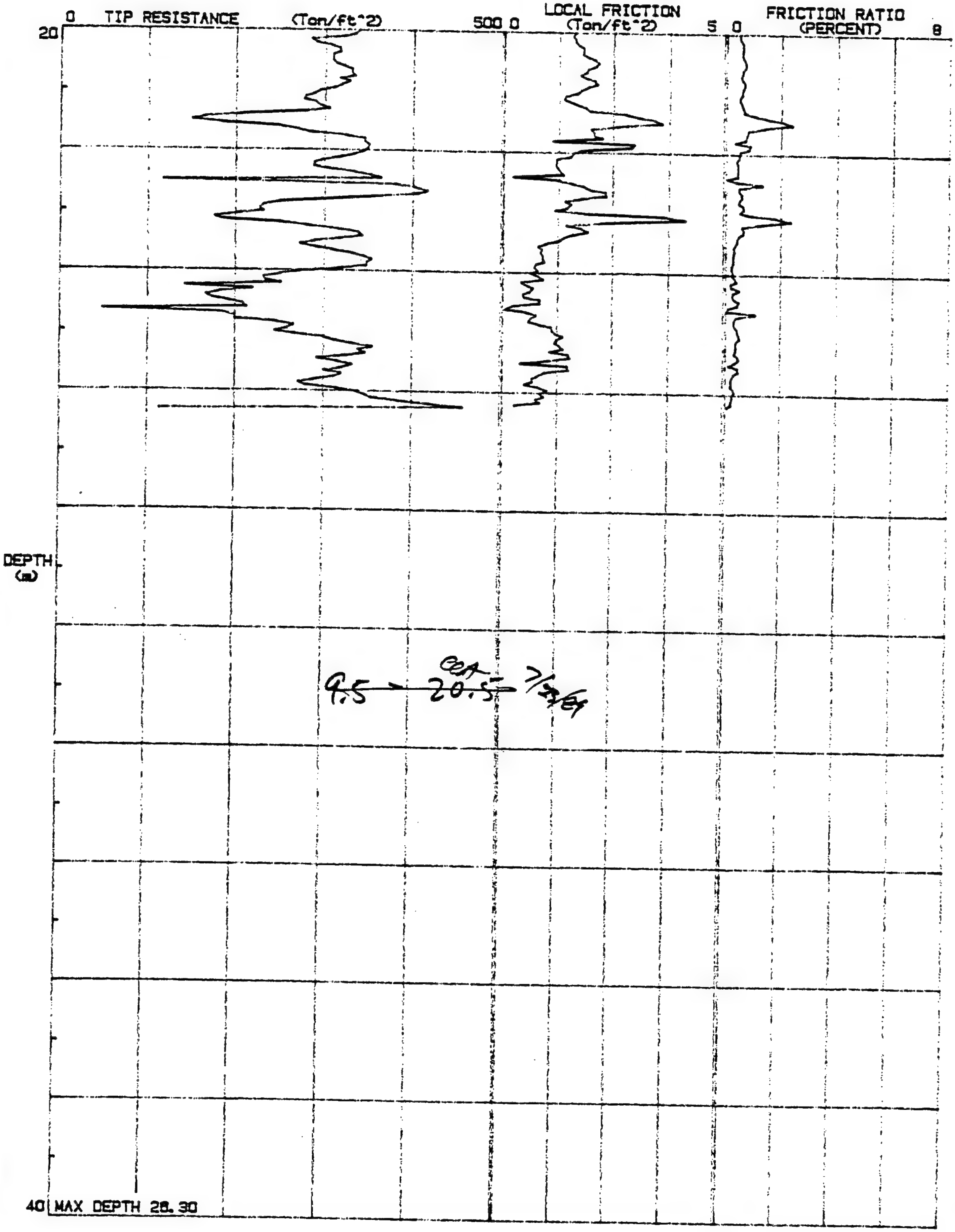
DATE : 07-22-89
LOCATION : CPT-14
FILE # : 23



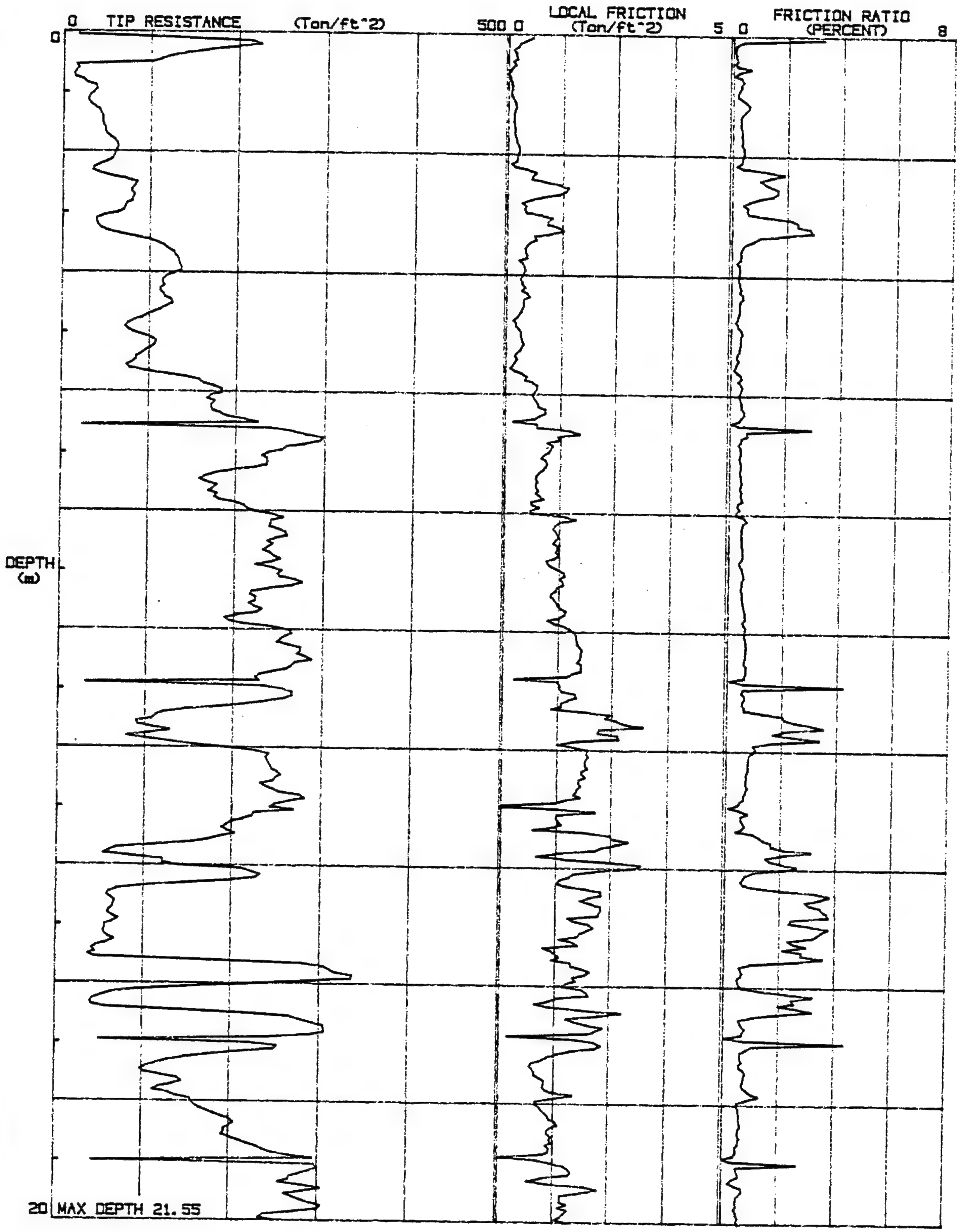
JOB # : 89-1024
DATE : 07-23-89
LOCATION : CPT-~~13~~ 15 ccA 7/23/89
FILE # : 24



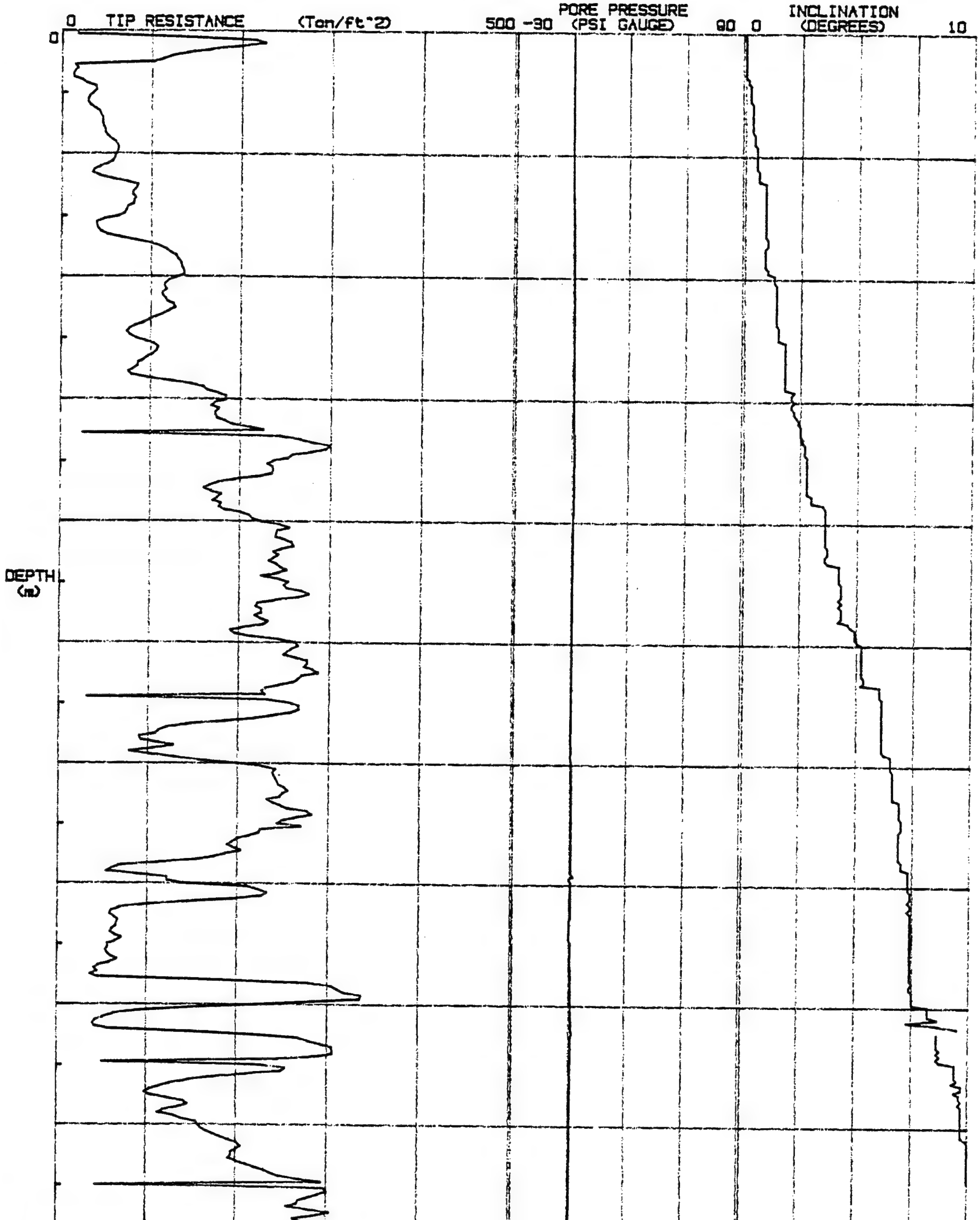
DATE : 07-23-89
LOCATION : CPT-~~13~~ 15 CCA 7/23/89
FILE # : 24



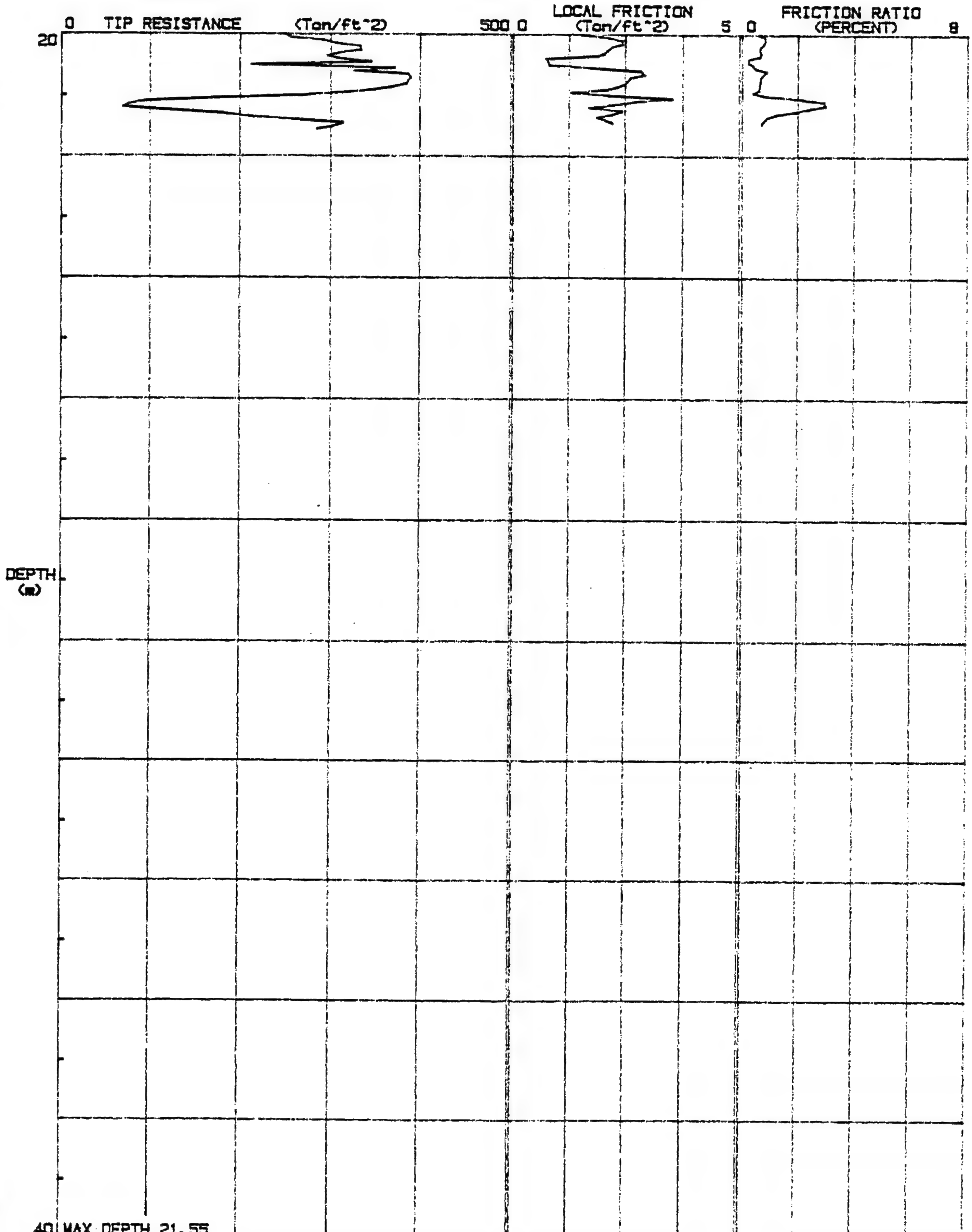
JOB # : 89-1024
DATE : 07-23-89
LOCATION : CPT-18
FILE # : 25

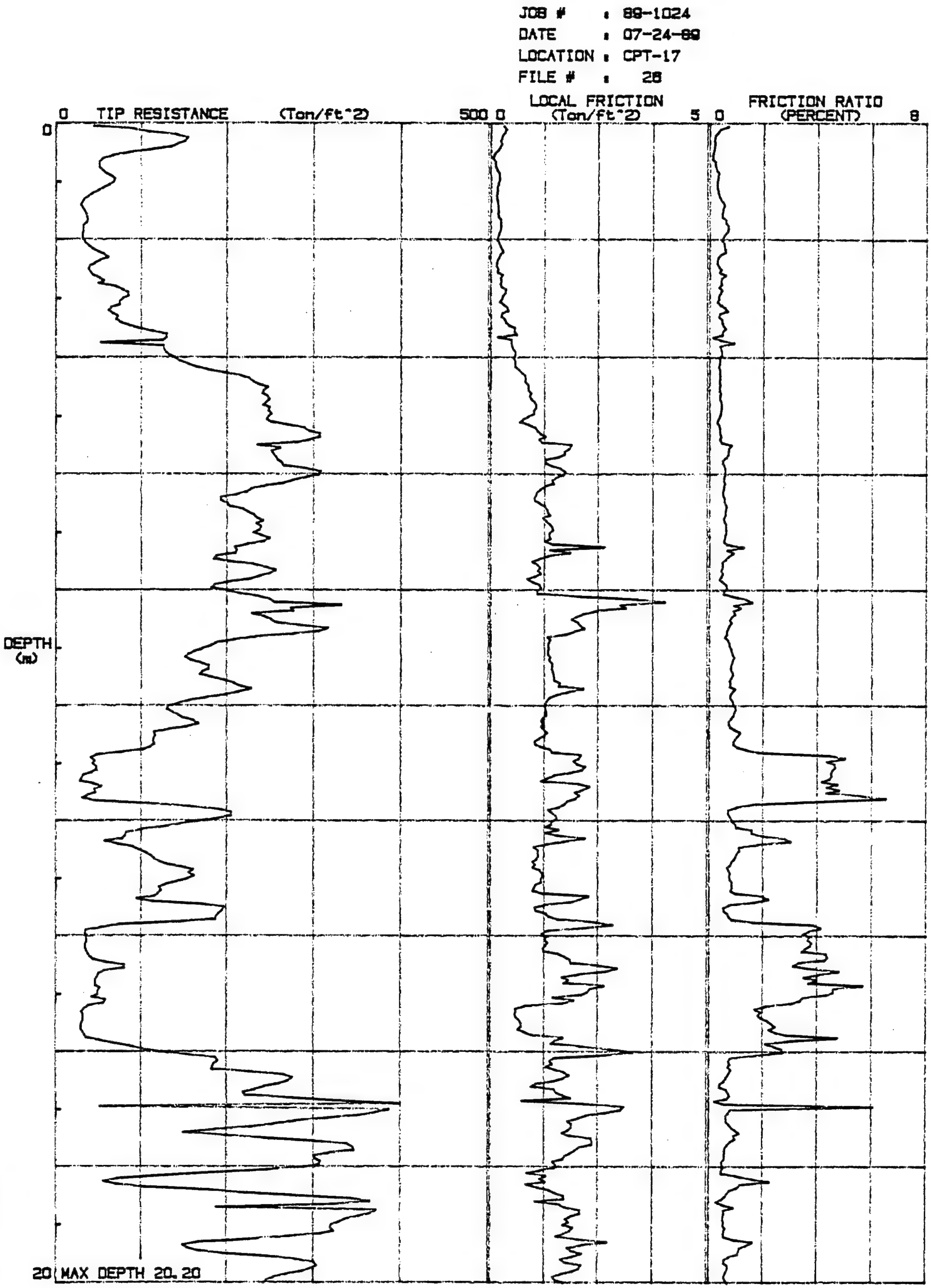


DATE : 07-23-89
LOCATION : CPT-18
FILE # : 25

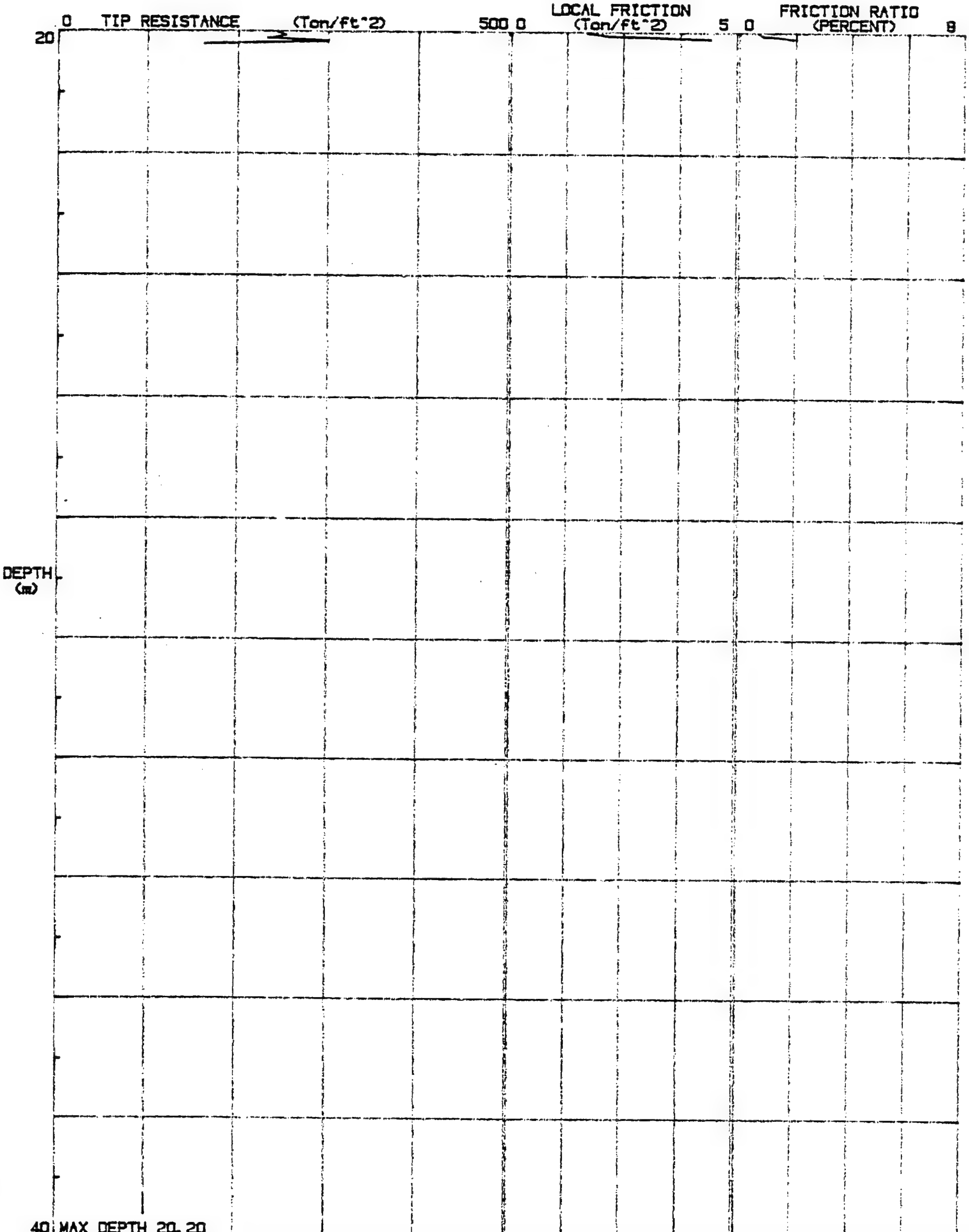


DATE : 07-23-89
LOCATION : CPT-18
FILE # : 25

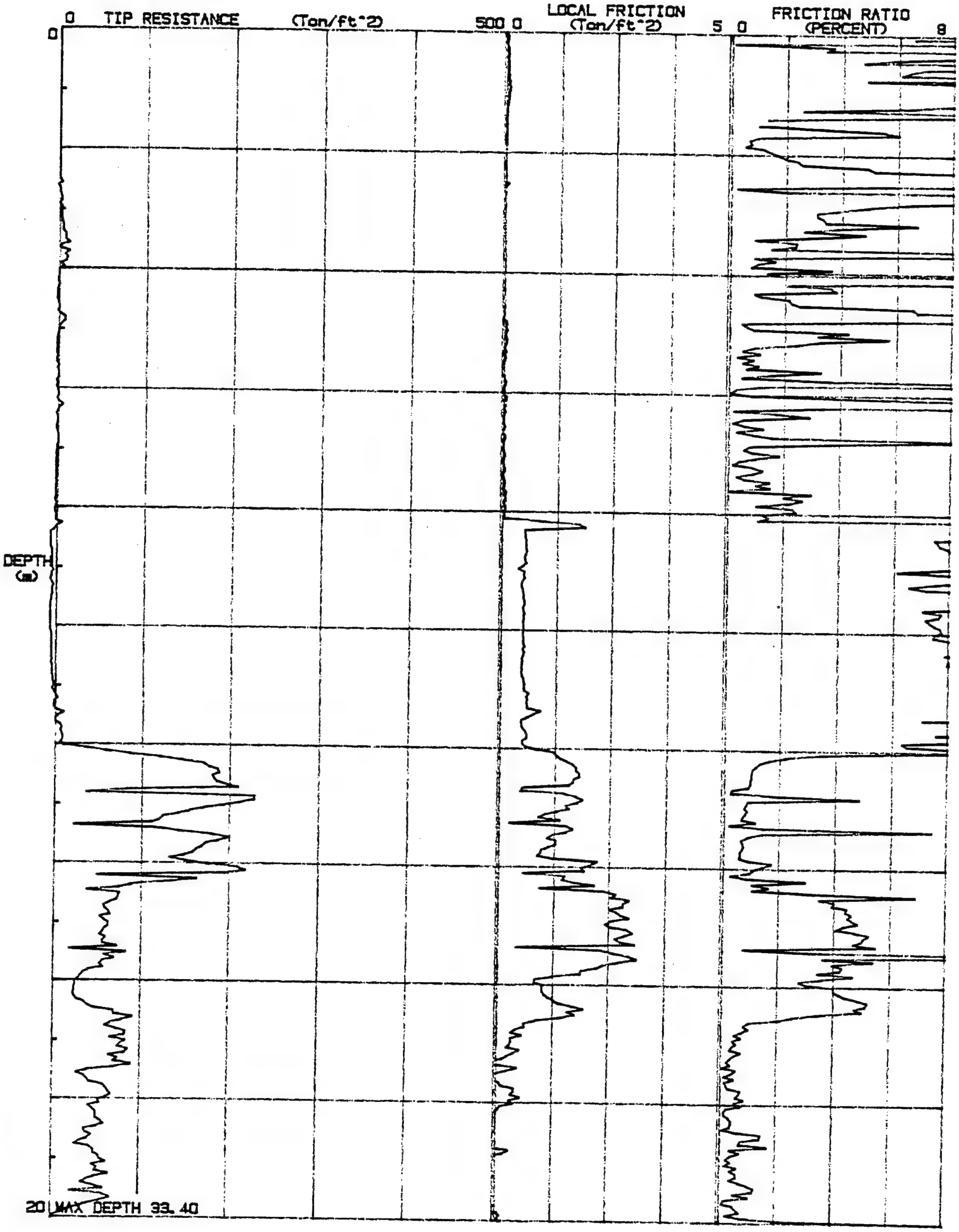



JOB # : 89-1024
DATE : 07-24-89
LOCATION : CPT-17
FILE # : 28
0 TIP RESISTANCE (Ton/ft^2) 500
0 LOCAL FRICTION (Ton/ft^2) 5
0 FRICTION RATIO (PERCENT) 8
DEPTH (m)
0
20
MAX DEPTH 20.20

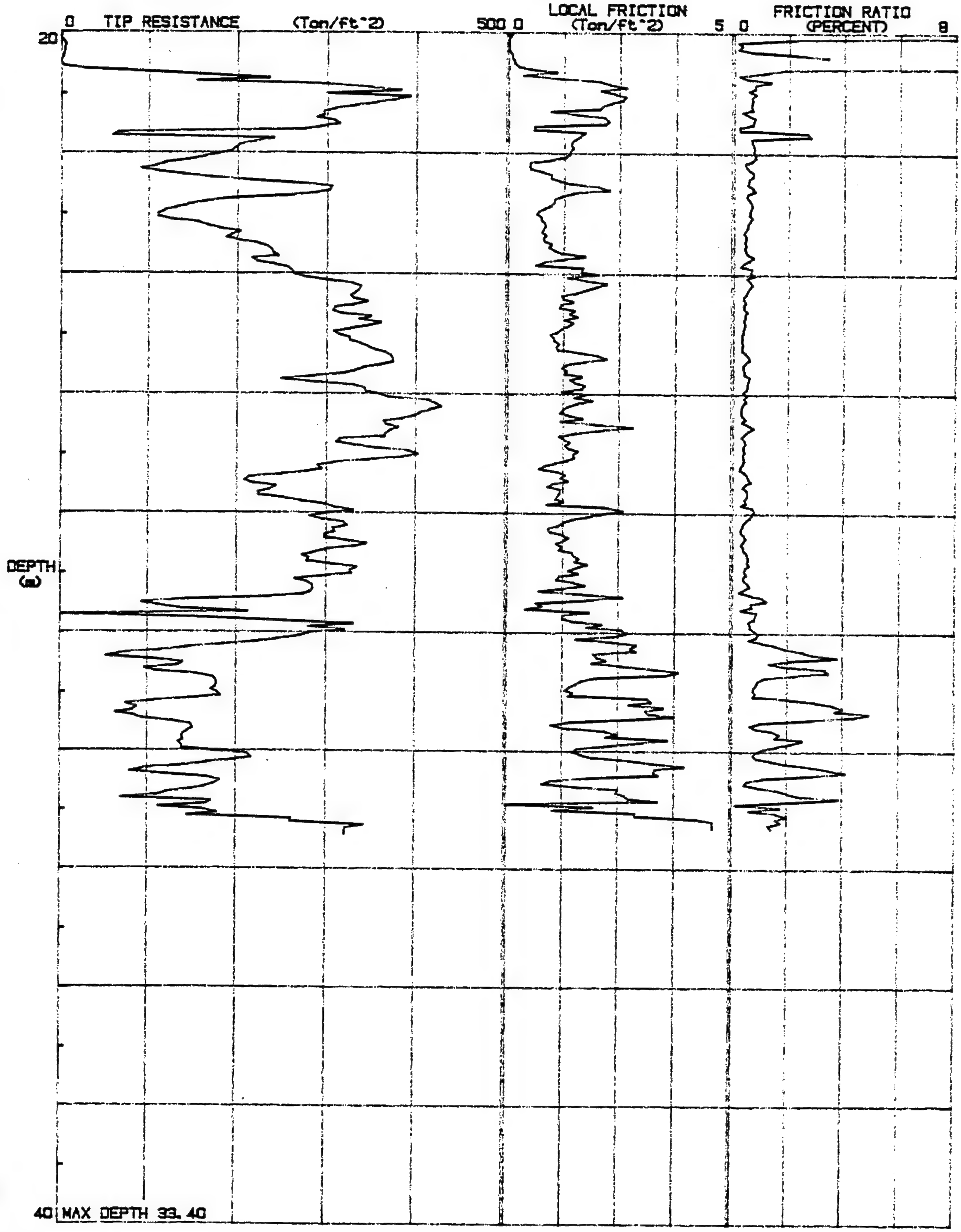
DATE : 07-24-89
LOCATION : CPT-17
FILE # : 28



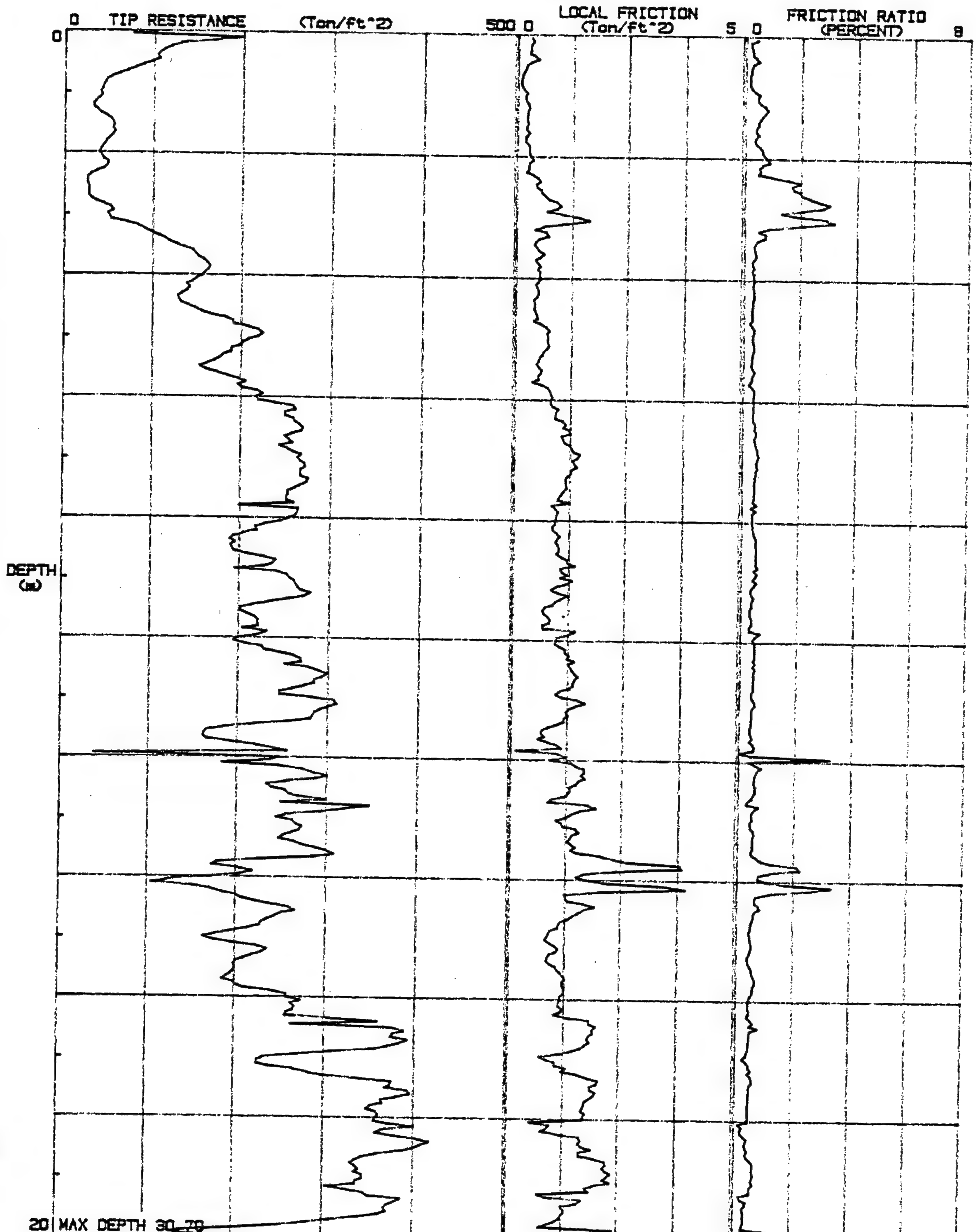
JOB # : 89-1024
DATE : 07-24-89
LOCATION : CPT-17 B
FILE # : 27

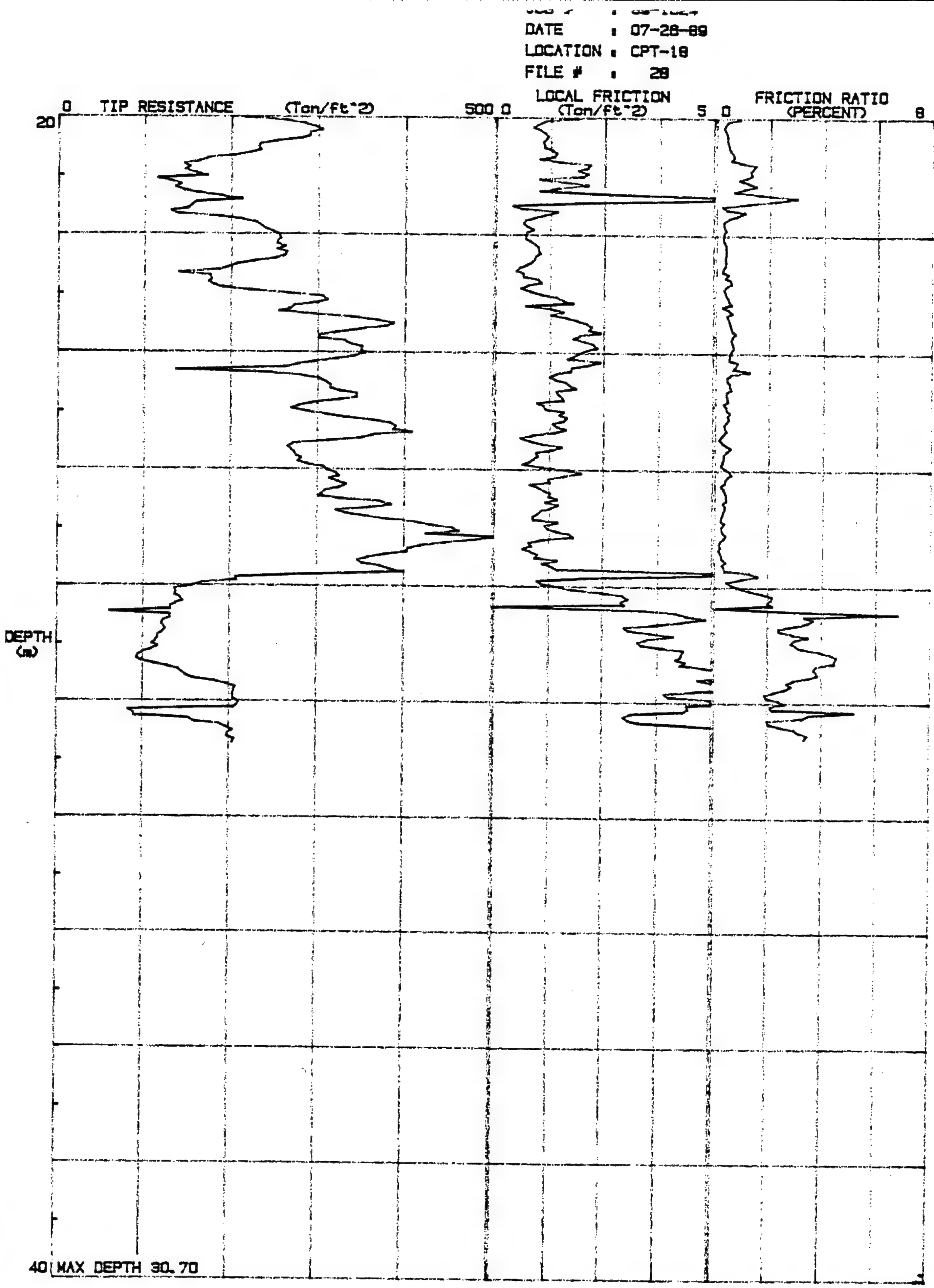


DATE : 07-24-89
LOCATION : CPT-17 B
FILE # : 27



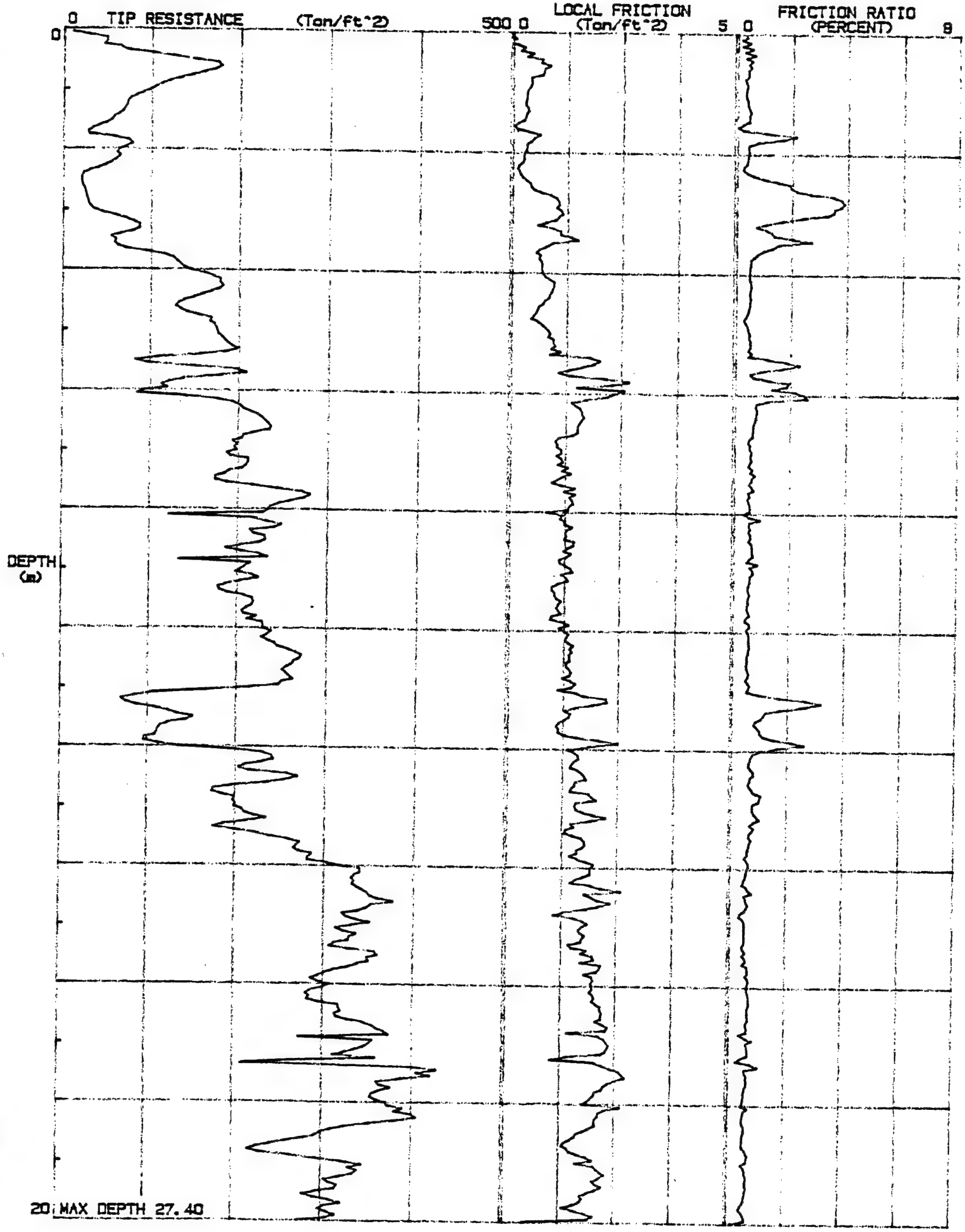
JOB # : 89-1024
DATE : 07-28-89
LOCATION : CPT-18
FILE # : 28

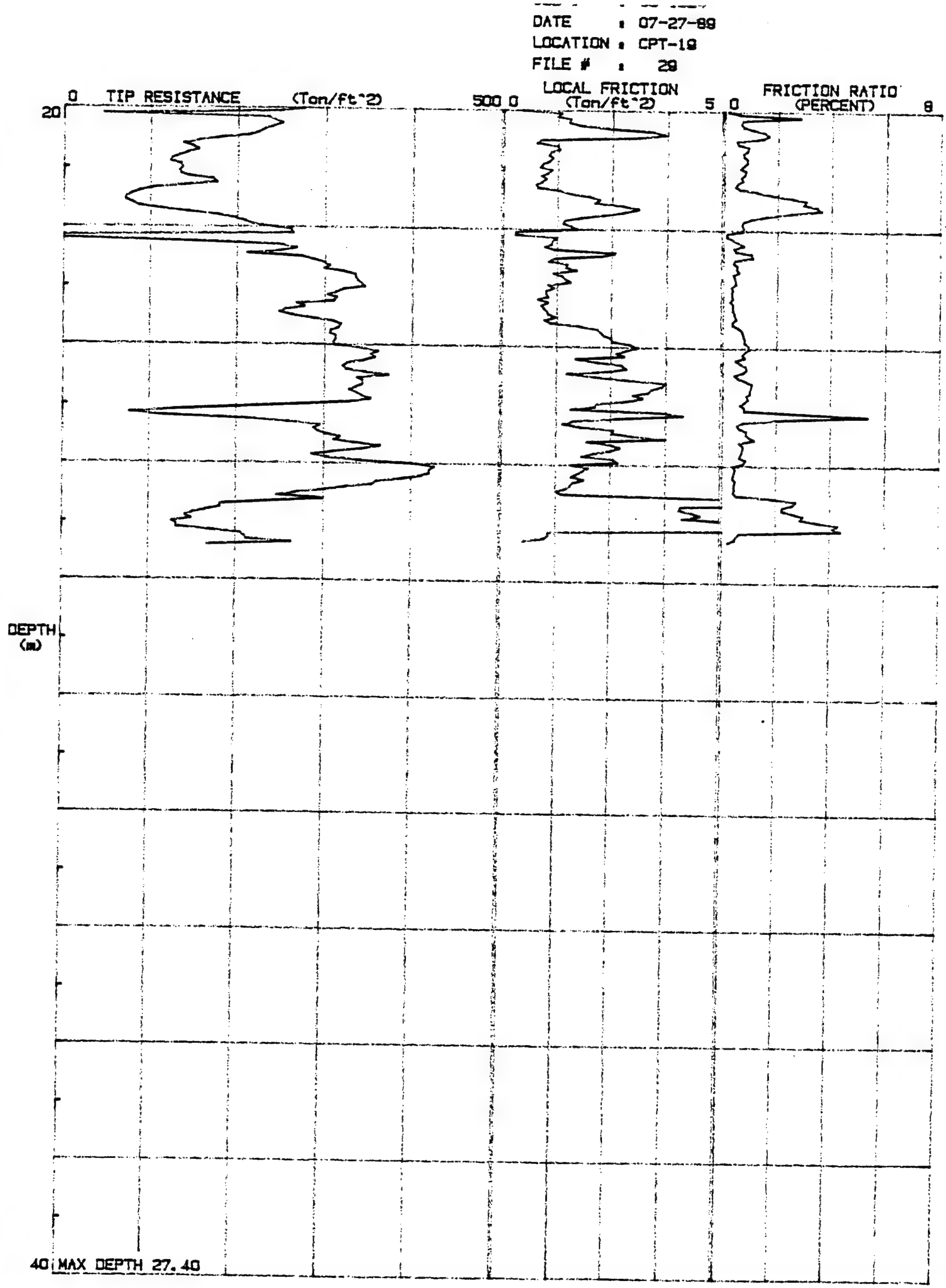




DATE : 07-28-89
LOCATION : CPT-18
FILE # : 28
0 TIP RESISTANCE (Ton/ft^2) 500
0 LOCAL FRICTION (Ton/ft^2) 5
0 FRICTION RATIO (PERCENT) 8
20
DEPTH (m)
40 MAX DEPTH 30.70

JOB # : 89-1024
DATE : 07-27-89
LOCATION : CPT-19
FILE # : 29

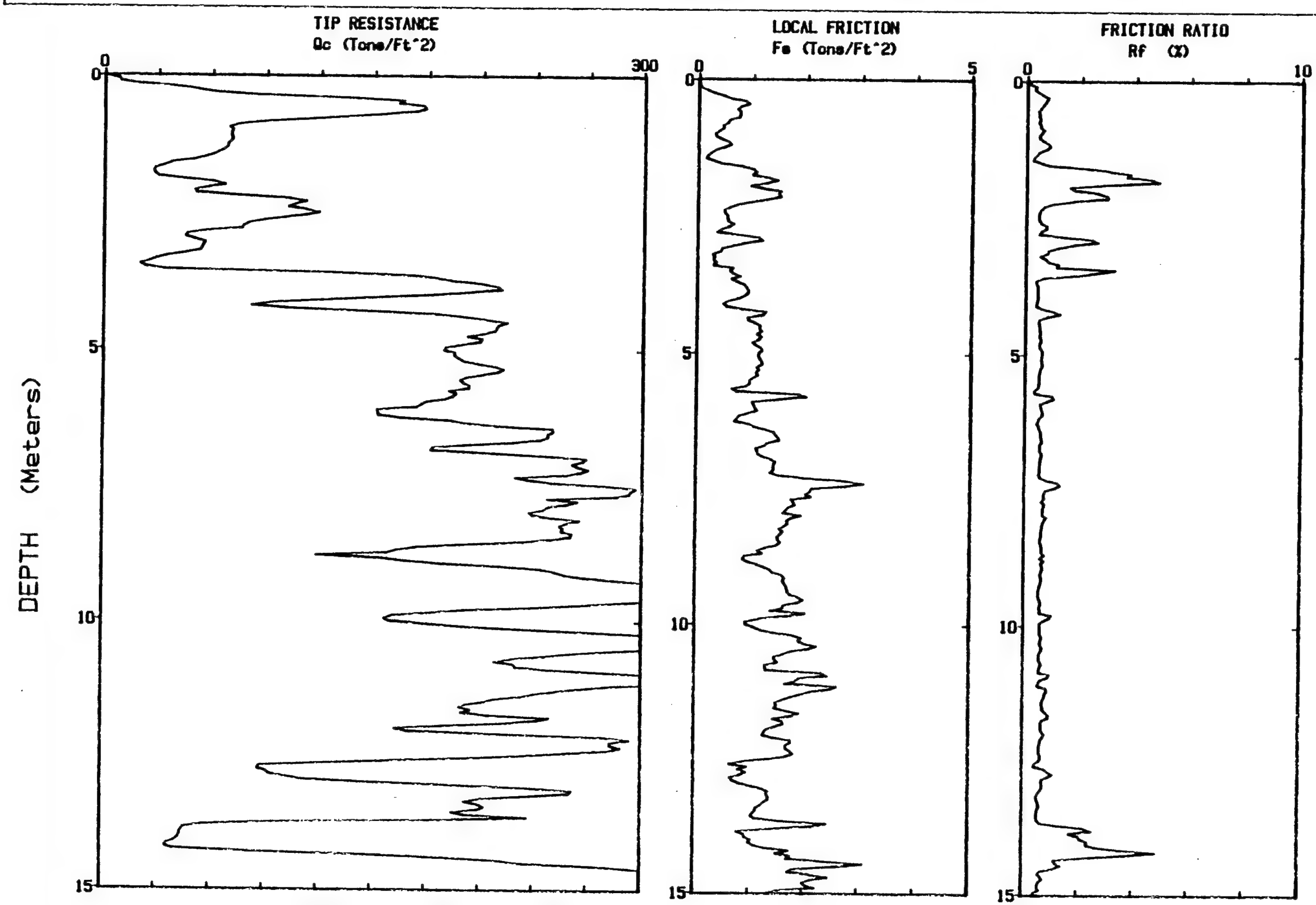



DATE : 07-27-88
LOCATION : CPT-19
FILE # : 29
0 TIP RESISTANCE (Ton/ft^2) 500
0 LOCAL FRICTION (Ton/ft^2) 5
0 FRICTION RATIO (PERCENT) 8
20
DEPTH (m)
40 MAX DEPTH 27.40

RAILYARD DBCP STUDY

Contractor: TERRA TECH. Test Date : 07-27-89 Page No: 1 / 2

Location: CPT-20 Elevation: UNKNOWN TERRA Job No.: 89-1024

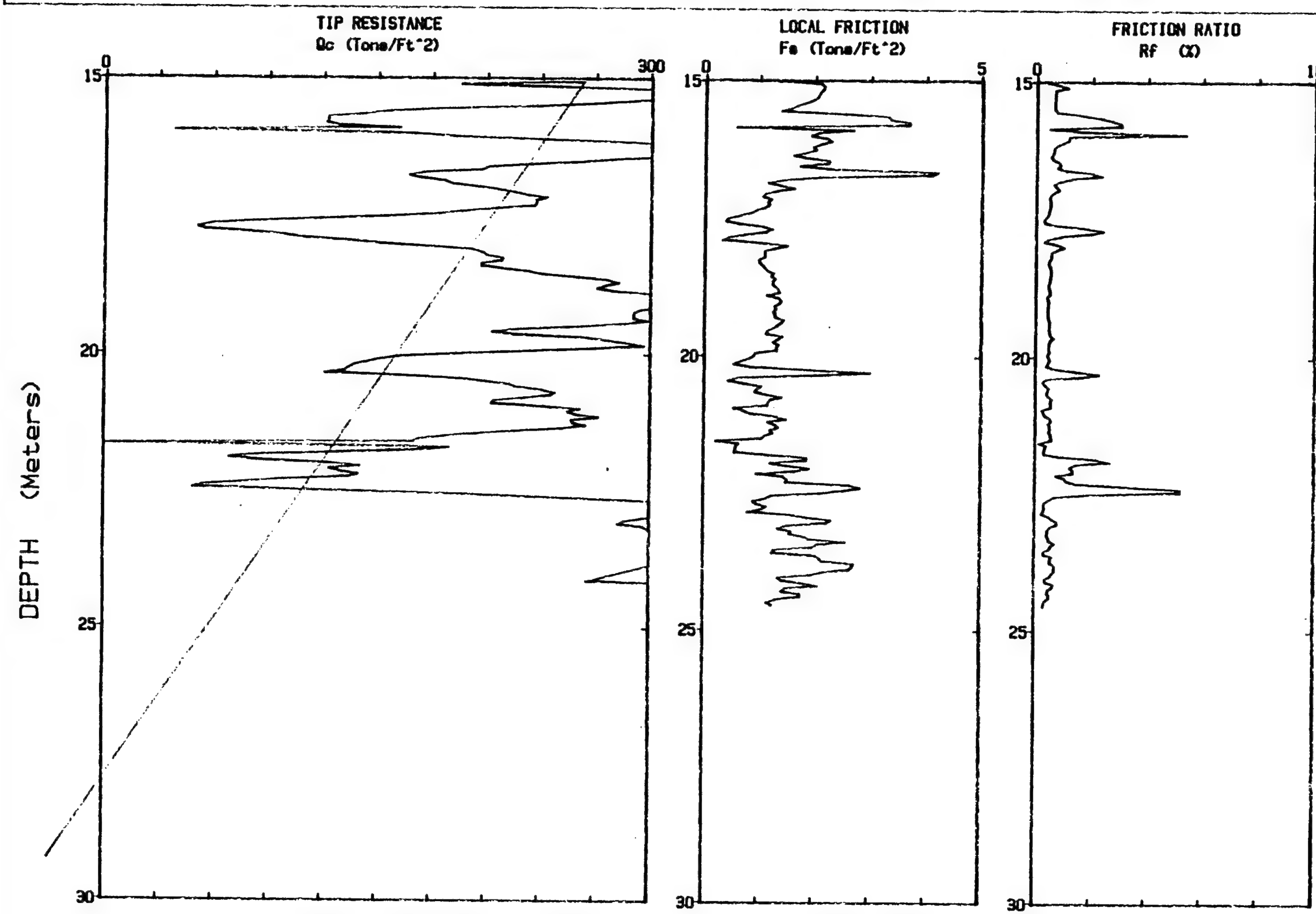


Depth Increment : .05 m Max Depth : 24.65 m

RAILYARD DBCP STUDY

Contractor: TERRA TECH. Test Date : 07-27-89 Page No: 2 / 2

Location: CPT-20 Elevation: UNKNOWN TERRA Job No.: 89-1024



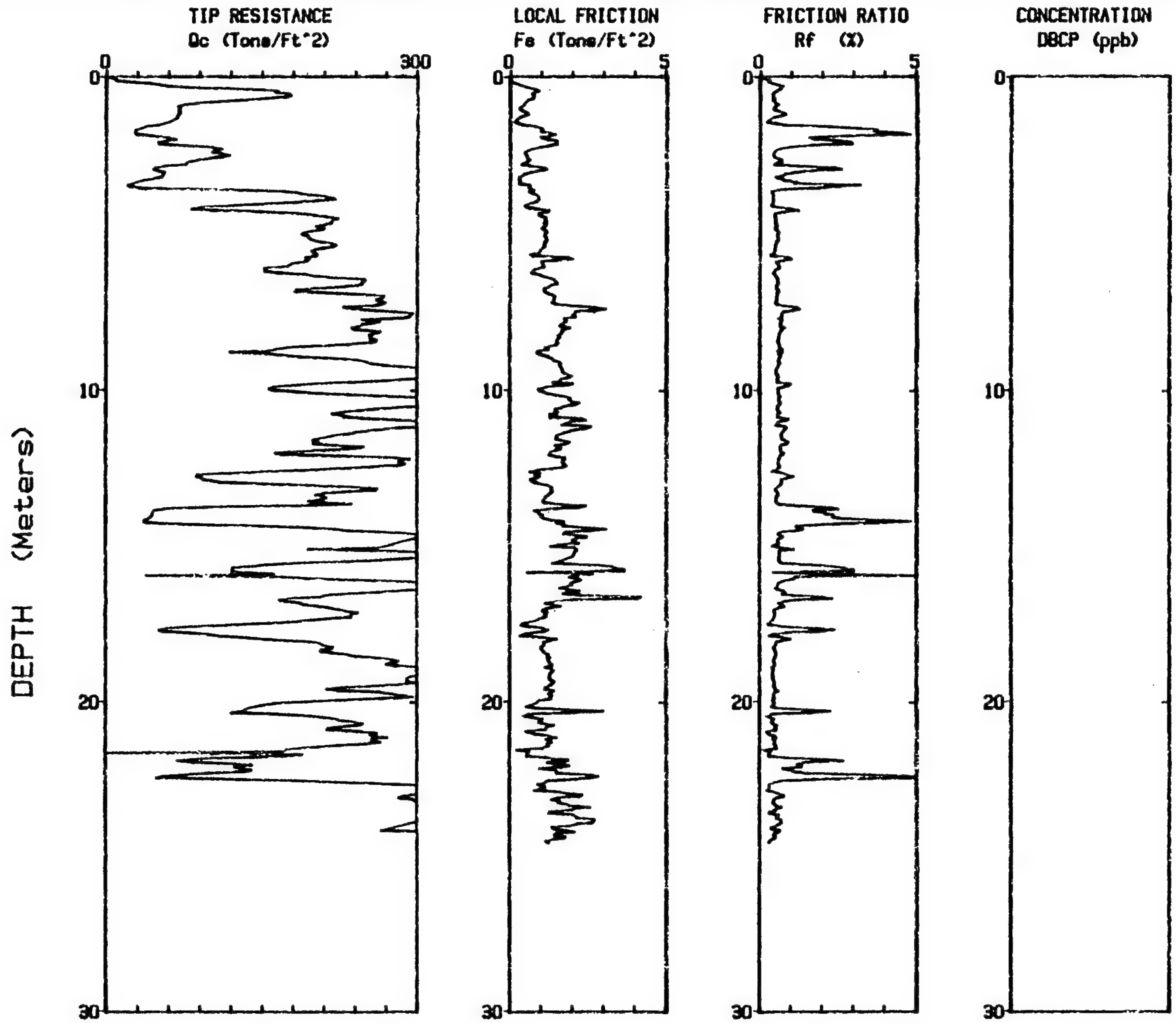
Depth Increment : .05 m

Max Depth : 24.65 m

RAILYARD DBCP STUDY

Contractor: TERRA TECH. Test Date : 07-27-89 Page No: 1 / 1

Location: CPT-20 Elevation: UNKNOWN TERRA Job No.: 89-1024



Depth Increment : .05 m Max Depth : 24.65 m

APPENDIX D

Groundwater Analytical Data for Monitoring Wells

Final Data Report for MKE Sampling Programs

Site Identification: WELL 03001

Sample Date: 04/12/89

Depth(ft): 0.0 TQ: B
Method: 00
Analysis Number: GKR011 Lab Number: MKE-Q8*7

Test Name	Bool	Value	Units	FC	Dilution	Moisture	QC	QC Spk
DBCP	LT	0.130	UGL		1.00	0.00		0.00

Final Data Report for MKE Sampling Programs

Site Identification: WELL 03009

Sample Date: 04/13/89

Depth(ft): 0.0 TQ: B
Method: Q8
Analysis Number: GKP012 Lab Number: E-RMA*54

Test Name	Bool	Value	Units	FC	Dilution	Moisture	QC	QC Spk
DBCP		0.900	UGL	C	1.00	0.00		0.00

Final Data Report for MKE Sampling Programs

Site Identification: WELL 03010

Sample Date: 04/12/89

Depth(ft): 0.0 TQ: B
Method: Q8
Analysis Number: GKR005 Lab Number: MKE-Q8*1

Test Name	Bool	Value	Units	FC	Dilution	Moisture	QC	QC Spk
DBCP	LT	0.130	UGL		1.00	0.00		0.00

Final Data Report for MKE Sampling Programs

Site Identification: WELL 03501

Sample Date: 04/12/89

Depth(ft): 0.0 TQ: B
Method: OB
Analysis Number: GKR006 Lab Number: MKE-QB#2

Test Name	Bool	Value	Units	FC	Dilution	Moisture	QC	QC Spk
DBCP		6.0	UGL	C	10.00	0.00		0.00

Final Data Report for MKE Sampling Programs

Site Identification: WELL 03502

Sample Date: 04/12/89

Depth(ft): 0.0 TQ: B
Method: Q8
Analysis Number: GKR010 Lab Number: MKE-Q8*6

Test Name	Bool	Value	Units	FC	Dilution	Moisture	QC	QC Spk
DBCP	LT	0.130	UGL		1.00	0.00		0.00

Final Data Report for MKE Sampling Programs

Site Identification: WELL 03503

Sample Date: 04/12/89

Depth(ft): 0.0 TO: B
Method: QB
Analysis Number: GKR007 Lab Number: MKE-QB*3

Test Name	Bool	Value	Units	FC	Dilution	Moisture	QC	QC Spk
DBCP		5.8	UGL	C	10.00	0.00		0.00
DBCP		10.	UGL	D	10.00	0.00		0.00
DBCP	LT	0.130	UGL		1.00	0.00	R	0.00

Final Data Report for MKE Sampling Programs

Site Identification: WELL 03504

Sample Date: 04/12/89

Depth(ft): 0.0 TQ: B
Method: QB
Analysis Number: GKR012 Lab Number: MKE-QB*8

Test Name	Bool	Value	Units	FC	Dilution	Moisture	QC	QC Spk
DBCP	LT	0.130	UGL		1.00	0.00		0.00

Site Identification: WELL 03523

Sample Date: 04/13/89

Depth(ft): 0.0 TQ: B
Method: Q8
Analysis Number: GKP013 Lab Number: E-RMA*55

Test Name	Bool	Value	Units	FC	Dilution	Moisture	QC	QC Spk
DBCP		23.	UGL	C	10.00	0.00		0.00

Sample Date: 04/14/89

Depth(ft): 0.0 TQ: B
Method: Q8
Analysis Number: GKP025 Lab Number: -RMA*126

Test Name	Bool	Value	Units	FC	Dilution	Moisture	QC	QC Spk
DBCP	LT	0.130	UGL		1.00	0.00	R	0.00

APPENDIX E

Analytical Data for Cone Penetrometer Sampling

MORRISON-KNUDSON/ROCKY MOUNTAIN ARSENAL/DENVER, COLORADO JOB#F-072-89-SG
06/28/89
CONDENSED DATA

SAMPLE	DBCP ug/l
Air	<0.0001
C1-G1.85m	<0.0006
C1-G1.85mD	<0.0006
C1-G1.85mDD	<0.0006
C1-G3.05m	<0.0006
TS1-G0.5m	<0.0006
TS1-G0.5mD	<0.0006
TS3-G0.5m	0.04
Air	<0.0006
07/01/89	
Air	<0.0004
C1-G17.75m	0.0004
CPT7-G17.55m	<0.0004
CPT7-W20.35m	0.2
CPT7-W20.35B	<0.006
CPT7-W24.0m	0.2
CPT7-W25.8m	0.07

Analyzed by: K. Tolman
Checked by: K. Tolman

Tracer Research Corporation

MORRISON-KNUDSON/ROCKY MOUNTAIN ARSENAL/DENVER, COLORADO JOB#F-072-89-SG
07/05/89
CONDENSED DATA

SAMPLE	DBCP ug/l
Air	<0.0006
CPT2-W24.2B	5
CPT10-W19.6B	0.4
CPT10-W21.8B	0.3
CPT10-W23.8B	0.09
CPT10-W2 .0A	<0.1
CPT8-W20.4	<0.01
CPT2-W19.95A	0.4
CPT2-W19.95B	3
CPT2-W19.95C	<0.01
03523-A	3
03523-B	1
03523-D	4
03523-E1	5
03523-E2	6
CPT7-W25.8	<0.04
CPT10-G19.0	0.0009
CPT2-W24.2D	6
CPT10-W23.8B	0.06

Analyzed by: K. Tolman
Checked by: K. Tolman
Proofed by: L. Kaplander

Tracer Research Corporation

MORRISON-KNUDSON/ROCKY MOUNTAIN ARSENAL/DENVER, COLORADO JOB#F-072-89-SG
07/07/89
CONDENSED DATA

SAMPLE	DBCP ug/l
Air	<0.00004
CPT1-W21.4F	<0.01
CPT1-W21.4B	<0.01
CPT3-W24.3F	0.1
CPT3-W24.3B	0.1
CPT4-W25.0F	<0.01
CPT4-W25.0B	<0.01
CPT6-W23.7F	0.01
CPT6-W23.7B	0.03
1ug/L #1	0.0107
1ug/L #2	0.0125
1ug/L #3	0.0130
1ug/L #4	0.0110
C3-W24.8F	<0.01
C3-W24.8B	<0.01
C4-W22.3B	<0.01
C4-W22.3F	<0.01

Analyzed by: K. Tolman
Checked by: K. Tolman
Proofed by: [illegible signature]

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CONDENSED DATA SHEET

Tracer Research Corporation

CONFIDENTIAL

DATE 07/25/89

SITE NAME RMA

LOCATION DENVER CO

CLIENT MKE

PAGE ____ OF ____

SAMPLE	DEPTH	COMPOUND	DBCP
		UNITS	µg/L
CPT-11-W-20.5B			0.004
CPT-11-W-26.0B			0.01
CPT-12-W-20.57B			9
CPT-12-W-26.49B			3
CPT-13-W-22.5B			0.7
CPT-13-W-27.8B			0.3
CPT-14-W-22.96B			0.04
CPT-14-W-25.18B			0.03

Notations: RF response factor
I interference with adjacent peaks
NA not analysed

Analysed by K TOMAN

CONDENSED DATA SHEET 8608621 Tracer Research Corporation

CONFIDENTIAL

DATE 07/26/89

SITE NAME RMA

LOCATION DENVER CO

CLIENT MKE

PAGE ___ OF ___

SAMPLE	DEPTH	COMPOUND / UNITS	OBCP µg/L
C-16-W-23.87B			4
C-16-W-23.87F			2
C-17-W-23.08B			0.1
C-17-W-23.08F			0.08
CPT-17B-W-28.15B			0.007
CPT-17B-W-28.15F			0.01
CHECK STANDARD			2.4
CPT-18-W-20.95B			0.04

Notations: RF response factor
I interference with adjacent peaks
NA not analysed

Analysed by K TOLMAN

Checked by

CONDENSED D TA SHEET 8608621

Tracer Research Corporation

CONFIDENTIAL

DATE 07/28/89

SITE NAME RMA

LOCATION DENVER CO

CLIENT MKE

PAGE ___ OF ___

SAMPLE	DEPTH	COMPOUND / UNITS	DBCP µg/L										
CPT-18-W-20.95B			0.04										
CPT-18-W-26.03B			0.03										
C-15-W-23.83B			6										
C-15-W-23.85F			2										
CPT-19-W-21.09B			0.07										
CPT-19-W-23.72B			0.02										
CPT-20-W-21.08B			0.007										
CPT-20-W-22.97B			0.5										

Notations: RF response factor
I interference with adjacent peaks

Analysed by K TOLMAN

PROJECT NUMBER
FIELD GROUP MK-DBCP

PROJECT NAME MK ENVIRONMENTAL SERV
PROJECT MANAGER DOYCE BLAIR

STORET CODE:					99133
METHOD CODE:					Q8
PARAMETER:					DBCP
UNITS:					UG/L
FLD.GRP.	#	SAMPLE ID	DATE	TIME	
MK-DBCP	1	CPT-2-A	07/03/89	13:49	5.32
MK-DBCP	2	03523-A	07/03/89	18:12	5.88
MK-DBCP	3	CPT-10-A	07/05/89	07:40	0.165

APPENDIX F

Soil Gas Test Survey Analytical Data

MORRISON-KNUDSEN ENGINEERS/ROCKY MOUNTAIN ARSENAL RAILROAD YARD/DENVER, COLORADO

Sample	Depth	Date	DBCP (ug/l)	DBCP (ug/g)
Air		02/13	<0.00004	N/A
SG-01	1'	02/13	0.006	N/A
SS-01	1'	02/13	N/A	0.04
SS-02	2'	02/13	N/A	<0.0004
SS-01	3'	02/13	N/A	0.006
SS-03	1'	02/13	N/A	0.06
SS-04	1'	02/13	N/A	0.003
SS-05	1'	02/13	N/A	0.4
Air		02/13	<0.00004	N/A
Air		02/23	<0.00004	N/A
SG-01	1'	02/23	0.01	N/A
Syst.Blk		02/23	<0.05	N/A
SS-01	2'	02/23	5	0.006
SG-02	1'	02/23	0.1	N/A
Syst.Blk		02/23	<0.1	N/A
SS-02	2'	02/23	250	0.2
Nitr.Blk		02.23	<0.00005	N/A
SG-03	1'	02/23	0.09	N/A
Syst.Blk		02/23	<0.05	N/A
SS-03	2'	02/23	37	0.07
Nitr.Blk		02/23	<0.00005	N/A
SG-04	1'	02/23	0.0002	N/A
Syst.Blk		02/23	<0.05	N/A
SS-04	2'	02/23	2	0.002

Notations:
I interference with adjacent peaks
NA not analyzed
Nitrg.Blk Nitrogen Blank
Syst.Blk System Blank

Analyzed by: J. Sherard

Checked by: D. Abranovic

Proofed by: L. Laplander

Tracer Research Corporation

MORRISON-KNUDSEN ENGINEERS/ROCKY MOUNTAIN ARSENAL RAILROAD YARD/DENVER, COLORADO

Sample	Depth	Date	DBCP (ug/l)	DBCP (ug/G)
SG-05	1'	02/23	34	N/A
Syst.Blk		02/23	<0.05	N/A
SS-05	2'	02/23	1,500	1
Nitrg.Blk		02/23	<0.0005	N/A
SG-06	1'	02/23	38	N/A
Syst.Blk		02/23	<0.05	N/A
SS-06	2'	02/23	2,800	2
SG-07	1'	02/23	0.009	N/A
Syst.Blk		02/23	<0.1	N/A
SS-07	2'	02/23	2	0.002
SG-08A	1'	02/23	0.06	N/A
Syst.Blk		02/23	<0.1	N/A
SS-08	2'	02/23	0.2	0.0002
SG-08B	1'	02/23	0.01	N/A
SG-09	1'	02/23	35	N/A
Syst.Blk		02/23	<0.1	N/A
SS-09	2'	02/23	410	0.5
Nitg.Blk		02/23	<0.0001	N/A
SG-10	1'	02/23	0.2	N/A
Syst.Blk		02/23	<0.05	N/A
SS-10	2'	02/23	19	0.02
Syst.Blk		02/23	<0.05	N/A
SS-11	2'	02/23	3	0.004
SG-12	1'	02/23	<0.00004	N/A
Syst.Blk		02/23	<0.05	N/A
SS-12	2'	02/23	0.2	0.0002
SG-13	1'	02/23	0.004	N/A
Syst.Blk		02/23	<0.1	N/A
SS-13	2'	02/23	0.8	0.001
Nitr.Blk		02/23	<0.00005	N/A
Syst.Blk		02/23	<0.2	N/A
SS-14	2'	02/23	2	0.002
Nitr.Blk		02/23	<0.00005	N/A
SG-15	1'	02/23	<0.00004	N/A
Syst.Blk		02/23	<0.2	N/A
SS-15	2'	02/23	<0.04	<0.00005

Notations:
I interference with adjacent peaks
NA not analyzed
Syst.Blk System Blank
Nitr Blk Nitrogen Blank

Analyzed by: J. Sherard

Checked by: D. Abranovic

Proofed by: L. Laplander

Tracer Research Corporation

MORRISON-KNUDSEN ENGINEERS/ROCKY MOUNTAIN ARSENAL RAILROAD YARD/DENVER, COLORADO

Sample	Depth	Date	DBCP (ug/l)	DBCP (ug/g)
Air		02/24	<0.00005	N/A
SS-16	2'	02/24	300	0.4
Nitrg.Blk		02/24	<0.00005	N/A
SG-16	4'	02/24	0.7	N/A
Syst.Blk		02/24	<0.05	N/A
SS-16	4'	02/24	46	0.05
SG-16	6'	02/24	1	N/A
Syst.Blk		02/24	<0.05	N/A
SS-16	6'	02/24	72	0.1
SG-16	10'	02/24	1	N/A
Syst.Blk		02/24	<0.2	N/A
SS-16	10'	02/24	51	0.05
SG-16	15'	02/24	0.7	N/A
Syst.Blk		02/24	<0.05	N/A
SS-16	15'	02/24	8	0.01
Nitrg.Blk		02/24	<0.00005	N/A
SG-16	20'	02/24	0.7	N/A
Syst.Blk		02/24	<0.05	N/A
SS-16	20'	02/24	81	0.07
SG-17	1'	02/24	0.2	N/A
Syst.Blk		02/24	<0.1	N/A
SS-17	2'	02/24	290	0.2
Syst.Blk		02/24	<0.05	N/A
SS-18	2'	02/24	50	0.04
SS-19	2'	02/24	16	0.02
SG-20	1'	02/24	0.001	N/A
Syst.Blk		02/24	<0.05	N/A
SS-20	2'	02/24	1	0.001
Air		02/24	<0.00005	N/A

Notations:
I interference with adjacent peaks
NA not analyzed
Nitrg.Blk Nitrogen Blank
Syst.Blk System Blank

Analyzed by: J. Sherard

Checked by: D. Abranovic

Proofed by: L. Saplander

Tracer Research Corporation

APPENDIX G

Railyard Soil Gas Survey Analytical Data

MORRISON KNUDSON/ROCKY MOUNTAIN ARSENAL/DENVER, COLORADO JOB #F-072-89-SG
06/05/89
CONDENSED DATA

SAMPLE	DBCP ug/l
Air	<0.00004
SGB1-1.5'	5
SGB2-1.5'	0.01
SGB3-1.5'	0.2
SGB5-1.5'	<0.00008
SGB6-1.5'	<0.00008
SGB7-2'	<0.00008
SGB8-1.5'	<0.00008
SGB9-1.5'	<0.00008
SGB10-1.5'	<0.00008
SGB11-1.5'	<0.00008
SGB15-1.5'	<0.00008
Air	<0.00004

Analyzed by: K. Tolman
Checked by: J. Olexa
Proofed by: L. Laplander

Tracer Research Corporation

MORRISON KNUDSON ENGINEERS/ROCKY MOUNTAIN ARSENAL/DENVER, COLORADO JOB#F-072-89-SG
06/06/89
CONDENSED DATA

SAMPLE	DBCP ug/l
Air	<0.0002
SG-B19-1.5'	<0.0003
SG-B20-1.5'	<0.0003
SG-A1-1.5'	<0.0003
SG-A3-1.5'	<0.0003
SG-A4-1.5'	<0.0003
SG-A5-1.5'	<0.0003
SG-A6-1.5'	<0.0003
SG-A8-1.5'	<0.0002
SG-A9-1.5'	<0.0002
SG-A10-1.5'	<0.0002
SG-A11-1.5'	<0.0002
SG-A12-1.5'	<0.0002
SG-A13-1.5'	<0.0002
SG-A14-1.5'	<0.0002
SG-A15-1.5'	<0.0002
SG-A16-1.5'	<0.0002
SG-A17-1.5'	<0.0002
SG-A18-1.5'	<0.001
SG-A19-1.5'	<0.001
SG-C1-1.5'	<0.0002
SG-C2-1.5'	<0.0002
SG-C3-1.5'	<0.0002
SG-C4-1.5'	<0.0002
SG-C5-1.5'	<0.0002
SG-C6-1.5'	<0.0002
SG-C7-1.5'	<0.0002
SG-C8-1.5'	<0.0002
SG-C9-1.5'	<0.0002
SG-C10-1.5'	<0.0002
SG-C11-1.5'	<0.0002
SG-C12-1.5'	<0.0002

Analyzed by: K. Tolman
Checked by: J. Olexa
Proofed by: L. Laplander

Tracer Research Corporation

MORRISON KNUDSON/ROCKY MOUNTAIN ARSENAL/DENVER, COLORADO JOB#F-072-89-SG
06/07/89
CONDENSED DATA

SAMPLE	DBCP ug/l
Air	<0.0002
SG-C13-1.5'	<0.0004
SG-C14-1.5'	<0.0004
SG-C15-1.5'	<0.0004
SG-C16-1.5'	<0.0004
SG-C17-1.5'	<0.0004
SG-C18-1.5'	<0.0004
SG-C19-1.5'	<0.0004
SG-D1-1.5'	<0.0004
SG-D2-1.5'	<0.0004
SG-D3-1.5'	<0.0004
SG-D4-1.5'	<0.0004
SG-D5-1.5'	<0.0004
SG-D6-1.5'	<0.0004
SG-D7-1.5'	<0.0004
SG-D8-1.5'	<0.0004
SG-D9-1.5'	<0.0004
SG-D10-1.5'	<0.0004
SG-D11-1.5'	<0.0004
SG-D12-1.5'	<0.0004
SG-D13-1.5'	<0.0004
SG-D14-1.5'	<0.0004
SG-D15-1.5'	<0.0004
SG-D16-1.5'	<0.0004
SG-D17-1.5'	<0.0004
SG-D18-1.5'	<0.0004
SG-D19-1.5'	<0.0004
SG-D20-1.5'	<0.0004
SG-E1-1.5'	<0.0004
SG-E2-1.5'	<0.0004
SG-E3-1.5'	<0.0004
SG-E4-1.5'	<0.0004
SG-E5-1.5'	<0.002
SG-E6-1.5'	<0.0004
SG-E7-1.5'	<0.0004
SG-E8-1.5'	<0.0004

Analyzed by: K. Tolman
Checked by: J. Olexa

Tracer Research Corporation

MORRISON-KNUDSON/ROCKY MOUNTAIN ARSENAL/DENVER, COLORADO JOB#F-072-89-SG
06/08/89
CONDENSED DATA

SAMPLE	DBCP ug/l
Air	<0.0003
SG-E9-1.5'	<0.0005
SG-E10-1.5'	<0.0005
SG-E11-1.5'	<0.0005
SG-E12-1.5'	<0.0005
SG-E13-1.5'	<0.0005
SG-E14-1.5'	<0.0005
SG-E15-1.5'	<0.0005
SG-E16-1.5'	<0.0005
SG-E17-1.5'	<0.0005
SG-E18-1.5'	<0.0005
SG-E19-1.5'	<0.0005
SG-F1-1.5'	<0.0005
SG-F2-1.5'	<0.0005
SG-F3-1.5'	<0.0005
SG-F4-1.5'	<0.0005
SG-F5-1.5'	<0.0005
SG-F6-1.5'	<0.0005
SG-F7-1.5'	<0.0005
SG-F8-1.5'	<0.0005
SG-F9-1.5'	<0.0005
SG-F10-1.5'	<0.0005
SG-F11-1.5'	<0.0005
SG-F12-1.5'	<0.0005
SG-F13-1.5'	<0.0005
SG-F14-1.5'	<0.0005
Air	<0.0003

Analyzed by: K. Tolman
Checked by: J. Olexa
Proofed by: L. Laplander

Tracer Research Corporation

MORRISON-KNUDSON/ROCKY MOUNTAIN ARSENAL/DENVER, COLORADO JOB#F-072-89-SG
06/09/89
CONDENSED DATA SHEET

SAMPLE	DBCP ug/l
Air	<0.0002
SG-F15-1.5'	<0.0004
SG-F16-1.5'	<0.0004
SG-F17-1.5'	<0.0004
SG-F18-1.5'	<0.0004
SG-F19-1.5'	<0.0004
SG-F20-1.5'	<0.0004
SG-G1-1.5'	<0.0004
SG-G2-1.5'	<0.0004
SG-G3-1.5'	<0.0004
SG-G4-1.5'	<0.0004
SG-G5-1.5'	<0.0004
SG-G6-1.5'	<0.0004
SG-G7-1.5'	<0.0004
SG-G8-1.5'	<0.0004
SG-G9-1.5'	<0.0004
SG-G10-1.5'	<0.0004
SG-G11-1.5'	<0.0004
SG-G12-1.5'	<0.0004
SG-G13-1.5'	<0.0004
SG-G14-1.5'	<0.0004
SG-G15-1.5'	<0.0004
SG-G16-1.5'	<0.0004
SG-G17-1.5'	<0.0004
SG-G18-1.5'	<0.0004
SG-G19-1.5'	<0.0004
SG-H1-1.5'	<0.0004

Analyzed by: K. Tolman
Checked by: J. Olexa
Proofed by: L. Laplander

Tracer Research Corporation

MORRISON KNUDSON/ROCKY MOUNTAIN ARSENAL/DENVER, COLORADO JOB#F-072-89-SG
06/12/89
CONDENSED DATA

SAMPLE	DBCP ug/l
Air	<0.0002
SG-H2-1.5'	<0.0005
SG-H3-1.5'	<0.0005
SG-H4-1.5'	<0.0005
SG-H5-1.5'	<0.0005
SG-H6-1.5'	<0.0005
SG-H7-1.5'	<0.0005
SG-H8-1.5'	<0.0005
SG-H9-1.5'	<0.0005
SG-H10-1.5'	<0.0005
SG-H11-1.5'	<0.0005
SG-H12-1.5'	<0.0005
SG-H13-1.5'	<0.0005
SG-H14-1.5'	<0.0005
SG-H15-1.5'	<0.0005
SG-H16-1.5'	<0.0005
SG-H17-1.5'	<0.0005
SG-H18-1.5'	<0.0005
SG-H19-1.5'	<0.0005
SG-H20-1.5'	<0.0005
SG-I1-1.5'	<0.0005
SG-I2-1.5'	<0.0005
SG-I3-1.5'	<0.0005
SG-I4-1.5'	<0.0005
SG-I5-1.5'	<0.0005
SG-I6-1.5'	<0.0005
Air	<0.0002

Analyzed by: K. Tolman
Checked by: J. Olexa
Proofed by: L. Laplander

Tracer Research Corporation

MORRISON KNUDSON/ROCKY MOUNTAIN ARSENAL/DENVER, COLORADO JOB #F-072-89-SG
06/13/89
CONDENSED DATA

SAMPLE	DBCP ug/l
Air	<0.0002
SG-I7-1.5'	<0.0004
SG-I8-1.5'	<0.0004
SG-I9-1.5'	<0.0004
SG-I10-1.5'	<0.0004
SG-I11-1.5'	<0.0004
SG-I12-1.5'	<0.0004
SG-I13-1.5'	<0.0004
SG-I14-1.5'	<0.0004
SG-I15-1.5'	<0.0004

Analyzed by: K. Tolman
Checked by: J. Olexa
Proofed by: L. Laplander

Tracer Research Corporation

MORRISON KNUDSON/ROCKY MOUNTAIN ARSENAL/DENVER, COLORADO JOB#F-072-89-SG
06/14/89
CONDENSED DATA

SAMPLE	DBCP ug/l
Air	<0.0001
SG-I16-1.5'	<0.0003
SG-I17-1.5'	<0.0003
SG-J1-1.5'	<0.0003
SG-J2-1.5'	<0.0003
SG-J3-1.5'	<0.0003
SG-J4-1.5'	<0.0003
SG-J5-1.5'	<0.0003
SG-J6-1.5'	<0.0003
SG-J7-1.5'	<0.0003
SG-J8-1.5'	<0.0003
SG-J9-1.5'	<0.0003
SG-J10-1.5'	<0.0003
SG-J11-1.5'	<0.0003
SG-J12-1.5'	<0.0003
SG-J13-1.5'	<0.0003
SG-J14-1.5'	<0.0003
SG-J15-1.5'	<0.0003
Air	<0.0001

Analyzed by: K. Tolman
Checked by: J. Olexa
Proofed by: L. Laplander

Tracer Research Corporation

MORRISON KNUDSON/ROCKY MOUNTAIN ARSENAL/DENVER, COLORADO JOB#F-072-89-SG
06/15/89
CONDENSED DATA

SAMPLE	DBCP ug/l
Air	<0.0001
SG-A20-1.5'	0.002
SG-A21-1.5'	<0.0002
SG-A22-1.5'	0.09
SG-A23-1.5'	<0.0002
SG-A24-1.5'	<0.0002
SG-A25-1.5'	0.4
SG-A26-1.5'	<0.0002
SG-A27-1.5'	<0.0002
SG-A28-1.5'	<0.0002
SG-A29-1.5'	<0.0002
SG-A30-1.5'	<0.0002
SG-A31-1.5'	<0.0002
SG-A32-1.5'	<0.0002
SG-A33-1.5'	<0.0002
SG-B40-1.5'	<0.0002
SG-B39-1.5'	<0.0002
SG-B38-1.5'	<0.0002
SG-B37-1.5'	<0.0002
SG-B36-1.5'	<0.0002
SG-B35-1.5'	<0.0002
SG-B34-1.5'	<0.0002
SG-B33-1.5'	<0.0002
SG-B32-1.5'	<0.0002
SG-B31-1.5'	<0.0002
SG-B30-1.5'	0.009

Analyzed by: K. Tolman
Checked by: J. Olexa
Proofed by: L. Kaplander

Tracer Research Corporation

MORRISON KNUDSON/ROCKY MOUNTAIN ARSENAL/DENVER, COLORADO JOB#F-072-89-SG
06/16/89
CONDENSED DATA

SAMPLE	DBCP ug/l
Air	<0.0001
SG-C20-1.5'	<0.0002
SG-C21-1.5'	<0.0002
SG-C22-1.5'	<0.0002
SG-C23-1.5'	<0.0002
SG-C24-1.5'	<0.0002
SG-C25-1.5'	0.02
SG-C26-1.5'	<0.0002
SG-C27-1.5'	<0.0002
SG-C28-1.5'	<0.0002
SG-C29-1.5'	<0.0002
SG-C30-1.5'	<0.0002
SG-C31-1.5'	<0.0002
SG-C32-1.5'	<0.0002
SG-D21-1.5'	<0.0002
SG-D22-1.5'	<0.0002
SG-D23-1.5'	0.004
Air	<0.0002

Analyzed by: K. Tolman
Checked by: J. Olexa
Proofed by: K. Laplander

Tracer Research Corporation

MORRISON KNUDSON/ROCKY MOUNTAIN ARSENAL JOB#F-072-89-SG
06/19/89
CONDENSED DATA

SAMPLE	DBCP ug/l
Air	<0.0001
SG-D24-1.5'	0.2
SG-D25-1.5'	0.04
SG-D26-1.5'	0.008
SG-D27-1.5'	<0.0002
SG-D28-1.5'	0.005
SG-D29-1.5'	<0.0002
SG-D30-1.5'	0.06
SG-D31-1.5'	<0.0002
SG-D32-1.5'	<0.0002
SG-E20-1.5'	<0.0002
SG-E21-1.5'	0.002
SG-E22-1.5'	0.2
SG-E23-1.5'	0.02
SG-E24-1.5'	0.04
SG-E25-1.5'	<0.0002
SG-E26-1.5'	0.1
SG-E27-1.5'	<0.0002
SG-E28-1.5'	<0.0002
SG-E29-1.5'	<0.0002
SG-E30-1.5'	0.2
SG-E31-1.5'	<0.0002
SG-F21-1.5'	<0.0002
SG-F22-1.5'	<0.0002
SG-F23-1.5'	0.01
SG-F24-1.5'	0.0006
SG-F25-1.5'	<0.0002
SG-F26-1.5'	<0.0002
SG-F27-1.5'	0.0008
SG-F28-1.5'	<0.0002
SG-F29-1.5'	<0.0002
SG-F30-1.5'	<0.0002
Air	<0.0001

Analyzed by: K. Tolman
Checked by: J. Olexa
Proofed by: L. Laplander

Tracer Research Corporation

MORRISON KNUDSON/ROCKY MOUNTAIN ARSENAL/DENVER, COLORADO JOB#F-072-89-SG
06/20/89
CONDENSED DATA

SAMPLE	DBCP ug/l
Air	<0.0001
SG-G20-1.5'	<0.0003
SG-G21-1.5'	<0.0003
SG-G22-1.5'	<0.0003
SG-G23-1.5'	<0.0003
SG-G24-1.5'	<0.0003
SG-G25-1.5'	<0.0003
SG-G26-1.5'	<0.0003
SG-G27-1.5'	<0.0003
SG-G28-1.5'	<0.0003
SG-H21-1.5'	<0.0003
SG-H22-1.5'	<0.0003
SG-H23-1.5'	<0.0003
SG-H24-1.5'	<0.0003
SG-H25-1.5'	<0.0003
SG-H26-1.5'	<0.0003
SG-I18-1.5'	<0.0003
SG-I19-1.5'	<0.0003
SG-I20-1.5'	<0.0003
SG-I21-1.5'	<0.0003
SG-I22-1.5'	<0.0003
SG-J15-1.5'	<0.0003
SG-J16-1.5'	<0.0003
SG-J17-1.5'	<0.0003
SG-J18-1.5'	<0.0003
Air	<0.0001

Analyzed by: K. Tolman
Checked by: J. Olexa
Proofed by: A. Kaplander

Tracer Research Corporation

MORRISON KNUDSON/ROCKY MOUNTAIN ARSENAL/DENVER, COLORADO JOB#F-072-89-SG
06/21/89
CONDENSED DATA

SAMPLE	DBCP ug/g
Air	<0.0001
SS-A34-2'	0.002
SS-A35-2'	<0.00001
SS-AB1-2'	0.02
SS-AB2-2'	0.006
SS-BC1-2'	<0.00001
SS-BC2-2'	0.01
SS-C33-2'	<0.00002
SS-C34-2'	0.0002
SS-A36-2'	<0.00001
SS-A37-2'	0.06
SS-A38-2'	0.05
SS-A39-2'	<0.00002
SS-A40-2'	<0.00002

06/22/89

Air	<0.0001
DS1-2'	<0.00001
DS2-2'	<0.000009
DS3-2'	<0.000006
DS4-2'	<0.00001
DS5-2'	<0.00002
SS-E31-2'	0.004
SS-E32-2'	<0.000009
SS-E33-2'	<0.000008
SS-E34-2'	<0.00001
SS-E35-2'	<0.00001
SS-E36-2'	<0.000009
SS-E37-2'	<0.000008
SS-E38-2'	0.0004
SS-E39-2'	0.07
SS-E40-2'	0.002

Analyzed by: K. Tolman
Checked by: J. Olexa
Proofed by: L. Laplander

Tracer Research Corporation

MORRISON KNUDSON/ROCKY MOUNTAIN ARSENAL/DENVER, COLORADO JOB#F-072-89-SG

Sample	Depth	Date	DBCP (ug/g)
SSB1	1.5'	06/05	I
SSB4	1.5'	06/05	0.000008
SSB12	2'	06/05	<0.000004
SSB13	1.5'	06/05	<0.000002
SSB14	1.5'	06/05	<0.000002
SSB16	1.5'	06/05	<0.000002
SSB17	2'	06/05	<0.000002
SSB18	2'	06/06	<0.000008
SS-A2	2'	06/06	<0.00002
SS-A7	2'	06/06	<0.000005
SS-I4	2'	06/12	<0.00001
SS-B21	2'	06/14	0.003
SS-B22	2'	06/14	0.02
SS-B2	2'	06/14	<0.00002
SS-B23	2'	06/14	0.001
SS-B24	2'	06/14	<0.00002
SS-B25	2'	06/14	0.01
SS-B3	2'	06/14	0.01
SS-B26	2'	06/14	<0.00001
SS-B27	2'	06/15	<0.000008
SS-B28	2'	06/15	<0.000009
SS-B29	2'	06/15	<0.000009

Analyzed by: K. Tolman
Checked by: J. Olexa
Proofed by: L. Kaplander

Tracer Research Corporation

APPENDIX H

Comments and Responses